XI. *On the Organization of the Fossil Plants of the Coal-Measures.*—Part XII.

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[Plates 27–34.]

In Part IX. of this series of memoirs (Phil. Trans., Part II., 1878, pp. 319–322) I described, under the generic name of *Astromyelon*, a series of stems, transverse sections of which might readily be, and for some time were, mistaken for sections of Calamites; but I pointed out the differences which separate widely these two types of stem. Attention was directed to the almost universally decorticated condition in which the *Astromyelons* were found; the only exceptions being one or two examples (*loc. cit.*, Plate 19, fig. 7, *d*), in which the vascular zone was surrounded by a thin cellular layer.

At the recent meeting of the British Association at York, Mr. Cash, of Halifax, and Mr. Hick, of Harrogate, described a remarkable stem, discovered by Mr. Binns in the Halifax beds, and to which they gave the name of *Myriophylloides Williamsonis.** I shortly afterwards suggested the desirableness of substituting the generic name of *Helophyton* as preferable to that of *Myriophylloides*, for reasons given in the note in which this suggestion was made.†

I subsequently received a letter from Mr. Spencer, of Halifax, telling me that he had obtained additional specimens of the new plant, which convinced him that it was a corticated state of the Oldham *Astromyelon* which I had previously described. All the specimens discovered up to the present time having been placed in my hands by my excellent auxiliaries, and undergone a careful investigation, I have no doubt about the correctness of Mr. Spencer's conclusion.

The plant proves to be a much more varied and remarkable one than I had previously thought.

The simplest form in which it has hitherto been met with is represented in fig. 1. This specimen, which is black and carbonised, is a transverse section of an axis which differs very widely from the ordinary forms of the Oldham *Astromyelon*. In its centre,

* This interesting communication has since been published in the Proceedings of the Yorkshire Geological and Polytechnic Society, vol. vii., part iv., p. 400, 1881.

† 'Nature,' Dec. 8, 1881, p. 124.

a, we have a somewhat confused admixture of cells and vessels, constituting a central axis, surrounded by an inner cortical zone, *b*, of radially compressed cells, arranged in an approach to regular circles, and passing outwards into a less regularly disposed series of much larger cells, *c*. From these latter, isolated lines of cells, *d*, radiate, chiefly in single rows, like the spokes of a wheel. The nave of this wheel is composed of a thick zone, *e*, of large and irregular parenchymatous cells. The drawing is enlarged 70 diameters—the maximum diameter of the section being about ·08 of an inch.

Fig. 2 represents the transverse section described by Messrs. CASH and HICK at York, enlarged 55 diameters. It presents very different features from those of fig. 1 so far as its central portion is concerned. At *a* we have a large medulla, about ·04 of an inch in diameter, composed of very regular parenchyma, and closely resembling that of the Oldham *Astromyelons*. The central cells are much larger than the peripheral ones, some of them being ·005 in diameter. This medulla is surrounded by narrow, imperfectly developed, and somewhat irregular zone of vessels, *b*, arranged in radiating lines. The concentric disposition of the cells of the innermost bark, *c*, is well shown in this section, as are the radiating lines of cells, *d*, connecting this inner bark with the peripheral parenchyma *e*. Though these lines of cells have been somewhat disarranged by external pressure, we have no difficulty in tracing a continuous zone of them from *d′* to *d″*.

Fig. 3 represents a very important section for which I am indebted to Mr. SPENCER: important because it demonstrates the identity of my *Astromyelon* and the *Myriophylloides* of CASH and HICKS in the most decisive manner. In my description of the former plant I directed attention to some features very characteristic of it. The chief of these was the distinct outline and peculiar form of the conspicuous vascular wedges constituting the exogenous zone (*loc. cit.*, Plate 19, fig. 1, *b*), and the relations of these wedges to the large medulla which that zone enclosed. The laminæ of each wedge, *b*, converge at their medullary extremity, where there exists small groups of what, in my previous memoir, I designated " a few vessels of somewhat larger size than those composing the rest of the vascular zone" (*loc. cit.*, p. 320). I cannot quite satisfy myself whether these are actually vessels or liquified cells.* In either case they bear a definite relationship to the vascular wedges with which each of the several small clusters of them is associated. In fig. 3 the characteristic medulla is conspicuous at *a*. The clusters of cells or vessels just referred to are seen at *a′*, and the distinctive forms of the vascular wedges are not difficult to trace, as is shown at *b*. The exogenous zone has undergone a much greater development in this specimen than in fig. 2. The identity of the plant with the *Myriophylloides* of CASH and HICKS is shown by the retention of a small portion of the cortex. The innermost layer is imperfectly retained at *c*, but the radiating cellular laminæ are sufficiently distinct at *d*, terminating in the outer layer of cortical cells at *e*.

* I have since obtained absolute proof that these are really vessels which may be regarded as constituting a medullary sheath.—July 6th, 1883.

Fig. 4 represents a section for which I am indebted to Messrs. CASH and HICKS. Virtually a vertical one, it has passed obliquely through the outer cortical parenchyma at its upper part and traversed the medulla at its lower end. The medullary cells are seen at *a*, corresponding closely with those represented by fig. 3, *a*, in Plate 19 of my Memoir IX.* The vessels of the exogenous zone are traversed almost radially at *b*, and more tangentially at *b′*. We next have the long, narrow, square-ended cells of the innermost bark at *c*. Above this tissue we obtain double light respecting the structure of the spokes of our vegetable wheel seen in the transverse sections. We learn that these radiating lines of cells are merely the transverse sections of long, vertical, cellular, radiating laminæ, *d*, which separate large intercellular lacunæ, *d″*, whilst at *d′*, *d′* we learn that the constituents of these laminæ are very regularly disposed cells elongated radially and having a mural arrangement. The cells of the outer cortical parenchyma, *e*, present no special peculiarities. The only additional feature noticeable in this section is a small bundle of vessels passing laterally outwards at *f*.

The three sections last described manifestly belong to the same plant in different stages of development; but I have now to direct attention to another series of specimens in my cabinet, some of which were first discovered by Mr. SPENCER, but to which others have been added by Mr. BINNS. So far as their cortical structures are concerned they are absolutely identical with those already described. Thus in each of the transverse sections, figs. 5 and 6, we have the inner cortical layer at *c*, the radiating laminæ at *d* enclosing the lacunæ at *d″*, and the outer cortex at *e*. The differences are seen in the structure of the vasculo-medullary axis—and especially of its central portion. This appears in both the sections figured to be largely if not entirely vascular, and others in my cabinet exhibit the same characteristic aspect. The exogenous vascular zone, *b*, also exhibits much less definitely the grouping of the radiating vascular laminæ into distinct wedges than is the case with the section, fig. 3. At the same time we fail to discover that grouping even in fig. 2, though the section there represented possesses the large cellular medulla so characteristic of fig. 3. In fig. 6 we find the lacunæ and radiating cellular laminæ replaced at *d‴* by a mass of coarse cellular parenchyma, and from which a vascular bundle is seen emerging at *f*.

Fig. 7 is an instructive section for which I am indebted to Mr. SPENCER. It appears to combine features seen in figs. 5 and 6 with others seen in fig. 1, and is further valuable since it illustrates the strong tendency to develop branches which seems to characterise this plant.

At the upper extremity, A, of the figure we have a nearly transverse section of an axis which has corresponded closely with fig. 1. At *a* we have an axial cluster of vessels, not arranged in any regular order, or surrounded by an exogenous zone. At *c* are the narrow elongated cells of the innermost cortex, intersected obliquely, whilst

* I may add that I have a true vertical section of another specimen of the new plant which is almost a facsimile of the main axis of fig. 2 in Plate 19 of my ninth memoir already referred to.

the radiating cellular laminæ are seen at *d* enclosing the large lacunæ at *d''*; these, in turn, being invested by the thick outermost parenchymatous cortex, *e*.

At the opposite end, B, of the section we find another branch, intersected very obliquely, and which is evidently tending outwards, in opposite directions. We here discover a central vascular axis, *a*, dividing dichotomously into a larger one, *a'*, and a smaller one, *a''*. These branches are successively surrounded by the inner bark, *c*, the radiating laminæ, *d*, with their enclosed lacunæ, *d''*, and the outermost cortex, *e*. At C a yet smaller vascular bundle, *a'''*, is passing laterally outwards. We thus have four branches passing in as many separate directions in this one specimen. None of these branches display any indication of a distinct central medulla, though cells appear to intermingle with the irregularly grouped vessels at A, *a*. It is thus clear that this section belongs to a plant in which, as in fig. 1, we have axial vascular bundles unsurrounded by an exogenous zone, whilst in figs. 5 and 6 we have the same plant in which such a zone is fully developed.

The vessels of the vascular bundles present some peculiarities, examples of which are represented in figs. 8–14. In describing the Oldham *Astromyelon* in my memoir, Part IX., I mentioned the extreme indistinctness if not almost entire absence of all traces of structure in the walls of these vessels, though in some few there were suggestions that they had been barred. The Halifax specimens differ from the Oldham ones in this respect, though there is room for doubting whether or not the latter shows fully their original nature. In all the figures, from 8 to 13 inclusive, a considerable, and often by far the greatest, part of the walls of the vessels are homogeneous and structureless. Thus in fig. 8 we have a single vertical series of small translucent, slightly oval, areolæ, the longer axes of which cross the vessel somewhat obliquely. In fig. 11 we have a similar arrangement, only the areoles are still more oblique, and more elongated transversely. In fig. 9 the areolæ are still small but almost circular. In fig. 10 the areolæ are more irregular both in size and number, but they still occupy the central area of the vessel. In fig. 12 the larger vessel approaches more nearly to an ordinary reticulated modification of the scalariform type of vessel, whilst in the smaller one the areolæ are larger in proportion to the diameter of the vessel than in most of the other examples, but in both the striking obliquity of the areolæ, seen in figs. 8 and 11, is again observable. The forms here described are those which characterise all the specimens figured, as well as others in my cabinet, except fig. 7; the vessels in the branching vascular bundle, B, *a*, of that section resemble figs. 13 and 14, which approach nearer to the barred type ordinarily met with amongst the fossil plants of the Coal-measures; but even fig. 14 lacks the extreme regularity which ordinarily characterises these barred forms. Do these figures represent the actual state of these vessels when living, or has mineralisation destroyed the details of the structure of their walls save along certain lines? Such specimens as figs. 8, 9, and 11 are so peculiar that I incline to adopt the former explanation, and the more so because at some future period I shall have to call attention to some similarly remarkable vascular tissues which prevail in the mineral charcoals so abundant in the coals of the Carboniferous rocks.

All the specimens now described are from the Halifax beds; but I have received from Mr. BUTTERWORTH a specimen from Oldham in which the bark, though in a very imperfect state, presents the essential features of the Halifax examples.

The above descriptions show that we either have one very variable plant characterised by a bark in the middle of which are numerous large lacunæ, separated from one another by vertical radiating cellular laminæ, or that we have two or more distinct plants which have the same peculiar form of bark, but which differ in the organization of their central vasculo-cellular axes. I am inclined to regard the former of these alternatives as affording the true interpretation of these specimens. I think there can be no doubt respecting one conclusion suggested by the peculiar structure of the bark, viz.: that it indicates a plant of more or less aquatic habits. A similar structure is found in several flowering plants such as *Myriophyllum* and the petioles of *Aponogeton.* It reappears in the *Marsileæ* and *Pilularia*, amongst Rhizocarps, and it is not essentially dissimilar from that of the living Equisetums. That the plant was a Phanerogam is most improbable. It differs alike from the recent Equisetums and the fossil Calamites in the entire absence of nodal joints and medullary phragmata. The question suggests itself, may it possibly be a representative of the Marsileaceæ?

I have examined many living species of *Marsilea*, and find that on making transverse sections of their rhizomes, not too far from their growing tips, we obtain results not dissimilar from those seen in fig. 7. We constantly obtain three different, but organically united, sections. One of these is that of the main stem, in which a horseshoe-shaped vascular bundle approaches so nearly to a perfect circle as almost to enclose a central cellular axis. Another is that of the base of a leaf-petiole. In this the fibro-vascular bundle is V-shaped, as in the secondary petioles of so many ferns. The third is a root-section in which the vascular bundle is central, and enclosed within those circular zones of cortical cells that are so common in the root-structures of Cryptogams. The existence of three such dissimilar structures in one section of a stem suggests the possibility of a similar explanation being applicable to the plant under consideration. The absence of the exogenous zone from the recent *Marsileæ*, whilst it is conspicuously present in our fossil, does not militate against my suggestion, since in this, as well as in other features, the *Astromyelon Williamsonis* does not diverge more widely from the living *Marsileæ* than the arborescent Lycopods of the Coal-measures do from their dwarfed living representatives, or than the Equisetums do from the Calamites.

Fig. 15 represents a section of a small organism from Halifax, ·02 of an inch in diameter, for which I am indebted to Mr. SPENCER. It may possibly belong to the plant just described, but this is doubtful. It consists of a central area, which is divided by a crucial arrangement of cells, *a*, into four lacunæ, *b*. The rest of the organism consists of a mass of parenchymatous disarranged cells of various shapes and sizes, many of which are filled with black carbonaceous matter, *c*. I can detect no vessels in the section. The division of the central portion into four lacunar cavities reminds us of the similar divisions in the leaves of *Isoetes.*

Psaronius Renaultii.

In my memoir, Part VII., pp. 10–13, I described, under the above name, some sections which I believed to belong to an arborescent fern, and in fig. 22**, *d*, I represented the only trace of a vascular bundle hitherto met with belonging to this plant. Mr. GEORGE WILD, of the Bardsley Collieries, Ashton-under-Lyne, has since furnished me with a much finer specimen, a section of which is represented in fig. 16. The vascular bundle, *a*, is quite perfect, and corresponds both in shape and size with several of those represented by CORDA, whilst the fragments of a second similar bundle at *a′* show that the section is but a portion of a large stem in which there has been at least one circle of similar bundles. Each of these vascular zones is enclosed within a thin phlœm sheath, *b*, whilst the fundamental tissue exhibits the small gum-canals, *c*, already described; some of these, *c′*, are filled with carbonaceous matter. The size of the bundle at its greatest diameter is 1·1, the figure being enlarged about 2½ times.

Zygosporites.

In my memoir, Parts IX. and X., I described some minute objects under the above name, and whilst recognising their striking resemblance to the zygospores of several Desmideæ, I declined to follow some of my French friends who regarded them as being true Desmids. A discovery by Mr. SPENCER in the Halifax beds has justified my doing so.

Fig. 17 represents an oblong sporangium containing several of these *Zygosporites* under conditions which leave no room for doubt that they are true spores. The sporangium is about ·042 in length; fig. 17 being enlarged about 110 diameters. Fig. 18 represents the portion containing the zygospores, enlarged about 290 diameters. The spore, fig. 18, *a*, is obviously identical with the form which I designated *Z. brevipes;* but the peripheral radii in fig. 18, *b*, are longer than in my fig. 51 (Memoir, Part X., Plate 19), and approach, in that respect, fig. 54 of the same plate, to which latter form I gave the name of *Z. longipes,* indicating that these are but extreme forms of one species. Other fragments now in my cabinet leave little, if any, doubt in my mind that these spores are identical with those of the fruit figured in my memoir, Part V., Plate 5, figs. 28, 29, and 30, under the name of *Volkmannia Dawsoni.** Under these circumstances the provisional name of *Zygosporites* may be can-

* This fruit was assigned to the genus *Volkmannia* at a time when that genus was much clearly less defined than it now is. BRONGNIART, going further even than had previously been done by UNGER,

celled, as no longer needed, the spores to which it was applied being recognized as those of *Volkmannia Dawsoni.*

Calamites.

Our knowledge of the structure of the cortical tissues of Calamites is yet very imperfect. A specimen from the Gannister bed at Moorside, near Ashton-under-Lyne, for which I am indebted to Mr. GEORGE WILD, supplies a new fact. In the memoir, Part IX., figs. 8–10 and 13, I have represented the primitive undifferentiated state of the cortical parenchyma of Calamites; and in figs. 14 and 15 of the same memoir, I have shown that a thick prosenchymatous layer was formed in the bark of some older stems. In Mr. WILD's specimen, fig. 19, the vasculo-medullary axis presents the usual features, except that the vascular wedges are more detached than ordinary owing to the partial disappearance of the cells of the primary medullary rays. The innermost bark, *a*, differs but little from the primitive state seen in the figs. 8–10 and 13 just referred to; but at *b* we have a hypodermal zone of specialised bundles of what seem to have been prosenchymatous cells. Each bundle has a triangular section, the apex being centripetal, and is from ·012 to ·008 from base to apex. The outermost bark, *c*, appears to have been a thin epidermal layer, some ·003 to ·002 in thickness. The peripheral border of this zone is sharply defined and entire, being wholly devoid of the crenulated contour so long supposed to have characterised the exteriors of sections of the Calamites. Every definite fact hitherto discovered demonstrates that those outer surfaces possessed neither longitudinal flutings nor nodal constrictions. Whether the fibrous bundles just described are the beginnings of the prosenchymatous zone shown in figs. 14 and 15 of my ninth memoir, or whether they are peculiar to some special form of Calamite, cannot now be determined. The specimen described has a diameter of ·25.

Lepidodendroid plants.

In several of my memoirs I have called attention to the gradual growth that took place in the diameter of the Lepidodendoid medulla owing to the multiplication of the medullary cells, and also to a contemporaneous increase that took place in the size of the surrounding non-exogenous vascular cylinder or "étui medullaire" of BRONGNIART, as well as in the number of its component vessels. Hitherto, however, I have failed to discover any example of *natura naturans* in either of these respects. But I found in a collection of sections submitted to me by Mr. NORMAN, of City Road,

united *Volkmannia* with *Asterophyllites*, believing the former to be the fruiting branches of the latter. But the limits and distinctive characteristics of the genus *Asterophyllites* are themselves undefined, and, as yet, *sub judice*. Since I cannot identify my *Volkmannia Dawsoni* with any of the genera recognized by SCHIMPER or by Professor WEISS, of Berlin, and I have not, as yet, obtained so accurate a knowledge of the orientation of the sporangiophores as would alone justify me in making it the type of a new genus, the strobilus may be left provisionally where I placed it in my previous memoir.

London, a section of a *Lepidodendron* of the type of *L. Harcourtii*, in which nearly every one of the cells is in a state of simultaneous meristemic division. Fig. 20 represents a small portion of this section. The entire stem has a diameter of about 1·75; the vascular cylinder is about ·37 and the medulla about ·3 in diameter. Fig. 20, *a*, are the large vessels of the vascular cylinder. At *b* we have the thick, older, cell-walls of the medullary cells, whilst at *c* we have the newly formed septa by which each older cell is becoming divided into two or more new ones. The older cells exhibit the form of regular parenchyma; the new ones are extremely irregular in size and form, and would obviously require to undergo a considerable expansion, leading to a steady enlargement of the entire medulla, before they attained to the regular forms of the parent cells. Every fact observed thus far indicates that the vascular cylinder, *a*, develops centripetally, and that the multiplication of the medullary cells here demonstrated to have existed was preparatory to the conversion of the outermost of them into new vessels. The known facts of enlargement in the sizes of and in the number of vessels composing the vascular cylinder thus receives a probable explanation.*

Halonia.

In my memoir, Part II., p. 222, *et seq.*, I described the organization of some *Haloniæ* in which the central axis consisted, as in most of the young Lepidodendroid branches, of a central medulla surrounded by a vascular, non-exogenous cylinder. Thanks to Professor YOUNG and Mr. J. YOUNG, of the Glasgow University, I am now able to describe another interesting form of *Halonia* from the Arran deposits of Laggan Bay. In my descriptions of the Lepidodendroid plants from that locality (Memoir, Part X., p. 494) I pointed out that in *all the small* Lepidodendroid twigs, occurring so abundantly in those beds, the central axis was a solid, non-cylindrical, bundle of vessels (*loc. cit.*, Plate 14, figs. 1 and 2). Fig. 21 represents a section of the Arran *Halonia* which has a mean diameter of about ·87—a small portion of its peripheral cortical tissue having disappeared. The central axis, *a*, consists of a solid rod of barred vessels—resembling, in this respect, the young twigs with which it was found associated in the Arran beds. The surrounding cortical layers consist, as usual, of an innermost bark at *b*, composed of rather compressed but regular parenchyma, the cells of which are small, averaging about ·0012 in diameter. The space, *c*, seems to have been occupied by very similar cells, only a few of which remain. At *d* we have a middle bark, composed of larger and coarser parenchymatous cells, and at *e* is the usual prosenchymatous layer, the small cells of which are arranged in radiating series. In the specimen from which my sections were prepared the protuberances so charac-

* Though this addition to the number of the vessels appears to be made at the centripetal border of the vascular cylinder, *a*, it must not be supposed that this addition reduces the diameter of the medulla. Unlike what occurs amongst Phanerogams, the medullæ of many *Lepidodendra* obviously continue to enlarge long after the development of the exogenous zone.—July 8, 1883.

teristic of the *Haloniæ* are sufficiently conspicuous, and in the sections we can readily distinguish between the vascular bundles going off to these protuberances, and those supplying the leaves. Three of the former are seen at *f*, *f*, *f*. They have a mean diameter of about ·004. In the case of the *Halonia* previously described, the corresponding bundle was formed by the detachment of a small but complete segment of the vascular cylinder leaving a break in the continuity of the latter. In the present case the bundle is formed in the way represented in the three transverse sections, figs. 22, 23, and 24. In all these sections, *a* represents a portion of the solid vascular axis of the branch. In fig. 22 two indentations at *b*, *b* are separating the clusters of vessels, *f*, from the main bundle. In fig. 23 the bundle, *f*, is almost entirely separated, whilst in fig. 24 it is completely detached from the axial bundle, and is moving outwards through the middle bark as in fig. 21, *f*, *f*. These bundles are distinguished from the foliar bundles by their size; fig. 25, *a*, represents a portion of the cylinder giving off a foliar bundle, *b*.

This section, drawn to the same scale as the other three, exhibits the relative sizes of these two classes of bundles. We further see that many of the larger ones proceeding to the tubercles are surrounded by small foliar bundles of their own—destined, doubtless, to supply the leaves clothing these prominences characterising the *Halonia*.

This hitherto undescribed form of *Halonia* raises anew the question whether or not Plate 10, figs. 1 and 2, of my Part X. is a younger state of the plant represented in figs. 3 and 4 of the same plate. The two are identical in every feature other than the structure of these axial bundles, which is solid in the one and a hollow cylinder enclosing medullary cells in the other. The present position of the question is as follows:—

As stated in my previous memoir, the central axis of each of the very young Lepidodendroid twigs, so abundant in the Laggan Bay deposit, consists of a solid vascular bundle having a diameter of ·012. The similar solid axis of the new *Halonia*, belonging to a branch of larger size, has a diameter of ·14. I have recently obtained from the same locality an ordinary Lepidodendroid branch of about the same dimensions as the *Halonia*, of which the axial bundle is also a solid one, with a diameter of ·14. This is the largest example I have met with having a *solid* bundle. On the other hand, the smallest of the many Lepidodendroid branches and stems from Arran which my cabinet contains, possessing a *hollow* cylindrical vascular axis, is that figured in my memoir, Part X., figs. 3 and 4. In that specimen the vascular zone surrounding the central medulla has a diameter of ·2, from which figure all these cylinders increase steadily in diameter, in the number of their component vessels, and in the dimensions of the cellular medulla which they enclose, until we reach the largest axial bundles of the arborescent stems.* The fact that all the specimens hitherto found *below* a certain diameter have the *solid* vascular bundle whilst all *above* that

* This increase seems to be partly explained by what I have said on p. 466 about fig. 20.

diameter have the *hollow* ones, inclines me to adhere to my former opinion that these differences are merely due to age: a conclusion strengthened by the fact that *solid* axial bundles are equally absent from *every* specimen of considerable size that we have as yet obtained from any British locality. At the same time it is possible that this opinion may some day require modification.

The late Mr. BINNEY held the view that the *Haloniæ* were the roots, and not the branches, of some Lepidodendroid plants. M. RENAULT, in his recent 'Cours de Botanique Fossile,' advocates the view that some *Haloniæ* are what he terms "Stigmarhizomes" or semisubterranean creeping stems. Structural evidence compels me to reject both these conclusions.* Mr. CARRUTHERS arrived at the same conclusion as I had done from his study of some specimens which he described in 1873.† Recently visiting the museum of the Leeds Philosophical Society, I found on their shelves the magnificent and most conclusive specimen of a branching *Lepidodendron*, the terminal subdivisions of which are true *Haloniæ*, represented in fig. 26. I am indebted to Professor MIALL for an excellent cast of this specimen, from which cast Mr. BROTHERS, of Manchester, prepared the beautiful photograph copied in the above figure. It is yet more perfect than Mr. CARRUTHERS' specimen, since its lower extremity, *a*, exhibits much more markedly than his corresponding ones do the elongated foliar cicatrices characteristic of the *Lepidodendra*. At the lower portion of the branch, A, these leaf-scars have exactly the same form as those of *L. selaginoides* and *L. elegans* of LINDLEY and HUTTON. After its first bifurcation, the two branches, B, B, still retain much of their Lepidodendroid features, though the leaf-scars gradually become less elongated vertically. Towards the upper part of each of the branches, B, B, we discover the first traces of the tubercles characteristic of *Halonia*. These become yet more conspicuous and numerous in the terminal branches, C, C, where we also find that the foliar cicatrices are equilateral rhomboids, instead of the vertically elongated scars seen at A; their vertical and transverse diameters being now about equal. The difference between the two forms is shown to be due in this instance, not only to differences between the several cortical layers, but to the fact that these branches, like their parent stems, have grown more in length than in breadth. This is proven by the circumstance that we can trace the gradations from the one form to the other in the same continuous cortical surface. These Halonioid branches are obviously identical with the *Halonia tortuosa* of LINDLEY and HUTTON.

* See memoir, Part II., p. 222, Phil. Trans., 1872. In the work referred to above, M. RENAULT endeavours to draw a distinction between *Haloniæ*, which he believes to be the subterranean rhizomes, and those which he recognizes as branches of *Lepidodendron*. He includes in the former class, which he thinks differs from his second one in the rarity with which dichotomous branching occurs in the *Haloniæ* belonging to it, the well-known *Halonia regularis*. This distinction is a purely imaginary one. *Halonia regularis* dichotomises freely.—July 7th, 1883.

† "On *Halonia* of LINDLEY and HUTTON and *Cyclostadia* of GOLDENBERG," Geol. Mag., vol. x., No. 4, April, 1873.

In my second memoir (Phil. Trans., 1872, p. 222), read in June, 1871, I said, "I have little doubt but that *Halonia* was a fruit-bearing branch of a *Lepidodendron;*" and in a note added in April, 1872,* I affirmed *absolutely,* "First, that *Halonia* belongs to the upper branches of a Lepidodendroid tree, consequently it cannot be a root;" "Secondly, we learn that *Halonia* is a specialised branch of a Lepidodendroid tree that is not itself a *Halonia.*" These conclusions were further supported by Mr. CARRUTHERS in his memoir on *Halonia* and *Cyclostadia,* already referred to as published in April, 1873, and in which the author, speaking of the specimen which he then described, says, "With *Bergeria* must go *Halonia* as a separate genus, seeing that it is only a condition of *Lepidophloios;* and it may be of other Lepidodendroid plants." The specimen now described is unquestionably not a *Lomatophloios* but a true *Lepidodendron.* The figure on Plate 8 is slightly reduced in size.

Sporocarpon.

In my tenth memoir (Phil. Trans., 1880) I figured in Plate 18, fig. 39, and described (p. 510), under the name of *Sporocarpon ornatum,* a curious form of what appeared to be some Cryptogamic fruit. I have recently received two additional specimens of this organism, one from Mr. EARNSHAW, of Oldham, and the other from Mr. WILD, of Ashton-under-Lyne, which, whilst they confirm my previously expressed conviction as to the character of this object, reveal some additional features connected with it. Mr. WILD's specimen, originally a perfect circle, but slightly damaged during the preparation of the section, is represented by fig. 27. As before described, this fruit is a spherical body with an undulating peripheral outline. In both the new specimens the undulations are more regular than in that previously figured, and in the centre, *a,* of each crenulated prominence there is a canal produced by reabsorbtion of some of the parenchymatous cells. On re-examining my original specimen I find some slight traces of a similar condition. On the other hand, in both my two new examples the peripheral clusters of large cells (*loc. cit.,* fig. 39, *d*) are wanting. These circumstances suggest that the latter are examples of a more advanced stage of growth than the former. It is not improbable that this structure has been primarily developed in the interior of some parenchymatous tissue, of which the large cells, *d,* of my original figure are remnants, but which fell off after the capsule became separated from its temporary surroundings.

Dadoxylon.

In my memoir, Part VIII., I figured (*loc. cit.,* Plate 8, figs. 44 and 46; Plate 9, figs. 47 and 48) and described (p. 230) some young branches of our British form of *Dadoxylon* in which vascular bundles are given off in pairs from the medullary border

* *Loc. cit.,* p. 225.

of the vascular cylinder, and observed respecting them, "This orientation of these small bundles from the innermost layers of the wood is suggestive of their primary relations to leaves rather than to branches;" and further pointed out that they differed only from similar leaf-bundles in living Conifers only in being in pairs instead of being single. From this I inferred that "Either two bundles went to one leaf with a double midrib, or the leaves were arranged in pairs."

Since these remarks were penned I have examined various living Conifers in hope of finding in some of them a similar organization: I have succeeded in the case of *Salisburia Adiantifolia*, but in it alone. Fig. 28 represents a transverse section of a twig of that plant of the first year's growth, made immediately below the terminal leaf-bud. At *a* we have the medulla and the xylem zone at *b*; *c* is the cambium layer with newly forming xylem and phloëm zones.* At *d* is an inner and at *e* an outer cortical zone. Many of the cells of the medulla and of the inner bark contain large sphæro-raphides, these two tissues thus furnished being portions of the primitive fundamental tissue; the outermost bark, *e*, being an incipient cork periderm. At *f*, *f* we find the xylem ring interrupted by extensions of the medulla—which connect the latter with the cortical fundamental layer. Two vascular bundles, *g*, are given off from the vascular zone, one on each side of this extension of the medulla, and proceed outwards, diverging but slightly as they ascend towards the periphery, which they reach in pairs, as at *g′*, *g′*. In fig. 29 we have a transverse section of the petiolar base of one of the outermost leaf-scales of the leaf-bud, in which we again find a pair of these bundles, *g*, entering the leaf-scale. The prosenchymatous tracheides of each of these bundles are arranged in six or seven parallel and somewhat fan-shaped, radiating rows. In the matured leaf these two bundles obviously subdivide to form the well-known venation of the *Salisburia*.

Seeing that this twin development of the foliar bundles appears to be limited, amongst living Conifers, to the *Salisburia*, in which plant it seems to hold a definite relationship to the peculiar multinerved structure and Adiantiform contour of the leaf, may we not recognize the probability that our British carboniferous *Dadoxylons* bore some remote genetic relations to the living Gingko? No such duplex leaf-bundle appears to have been detected in any of the fine examples of *Cordaites* and their allies discovered by M. GRAND-'EURY in the St. Étienne deposits. This Salisburian form seems to be confined to our British *Dadoxylons*. That this similarity of contour in the arrangement of the leaf-bundles is not merely accidental is rendered the more probable by the fact that transverse sections of young twigs of the ancient and modern plants display corresponding identities. Thus a section of the bark of a young *Dadoxylon*† corresponds closely with the similar section of a *Salisburia*, fig. 28, in both of which the bark is separated into an outer coarsely cellular periderm and an inner one composed of much more delicate elements. This observation applies to the

* The section was made in April.

† See Memoir VIII., fig. 34.

Salisburia, whether in its young state, when the inner bark consists, as represented in fig. 28, of undifferentiated primitive parenchyma, or, in a later stage of growth, when the bark is distinctly differentiated into an inner translucent phloëm and an external phellem layer. These correspondences between the carboniferous *Dadoxylon* and the living *Salisburia* suggests another query. The resemblances between the fossil *Trigonocarpums* of the Coal-measures and the fruits of the Gingko have long been noticed. Do not the facts just mentioned increase the probability that these *Trigonocarpums* are the fruits of *Dadoxylon?* I not only think they do, but these facts suggest the further possibility, not to say probability, that our *Dadoxylons* may be the remote Carboniferous ancestors of the oolitic *Baierias*—already recognized as the ancestral forms whence sprang the *Salisburias* of Cretaceous and yet more modern times.

I have again to recognize my obligations to Messrs. CASH, SPENCER, and BINNS, of Halifax; to Mr. HICK, of Harrogate; to Mr. WILD, of Ashton-under-Lyne; and to Messrs. BUTTERWORTH and EARNSHAW, of Oldham, for their valuable aid in searching for specimens calculated to aid my investigations.

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Astromyelon Williamsonis.

Fig. 1. Transverse section of a non-exogenous branch (?). Enlarged 70 diameters. *a.* Vasculo-cellular axis. *b* and *c.* Inner cortical zones. *d.* Radiating cellular laminæ. *e.* Outer cortical parenchyma. Mr. SPENCER.

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Fig. 9. Form of vascular tissue. Enlarged 267 diameters.

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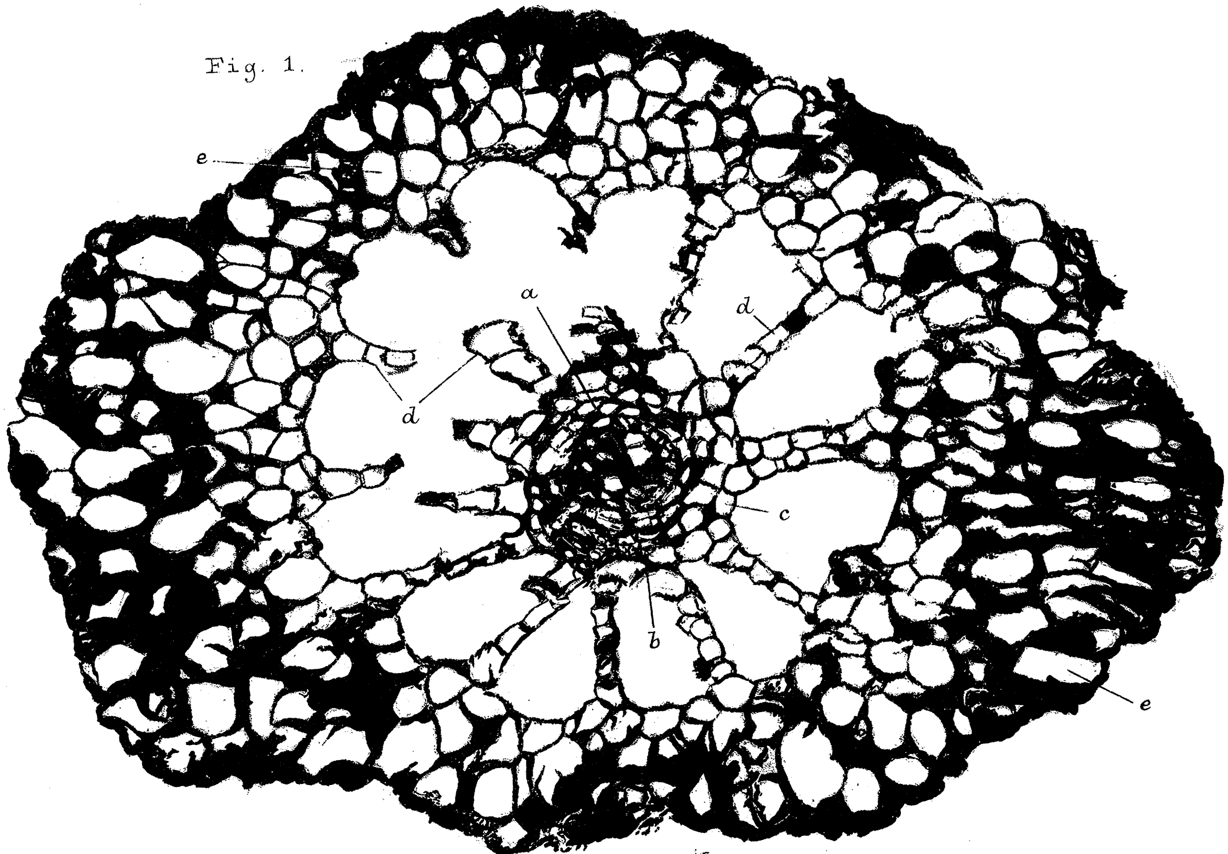
Fig. 1.



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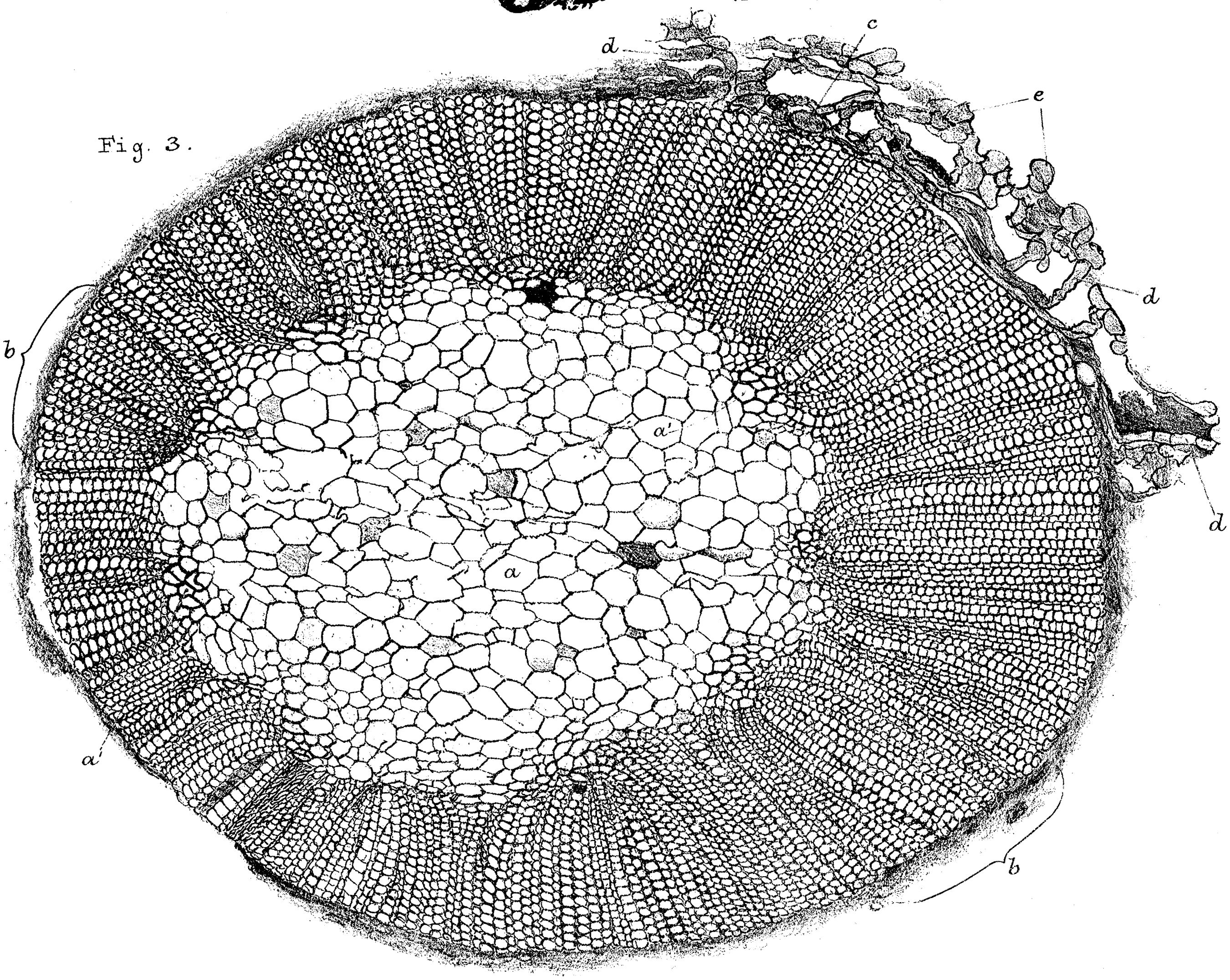

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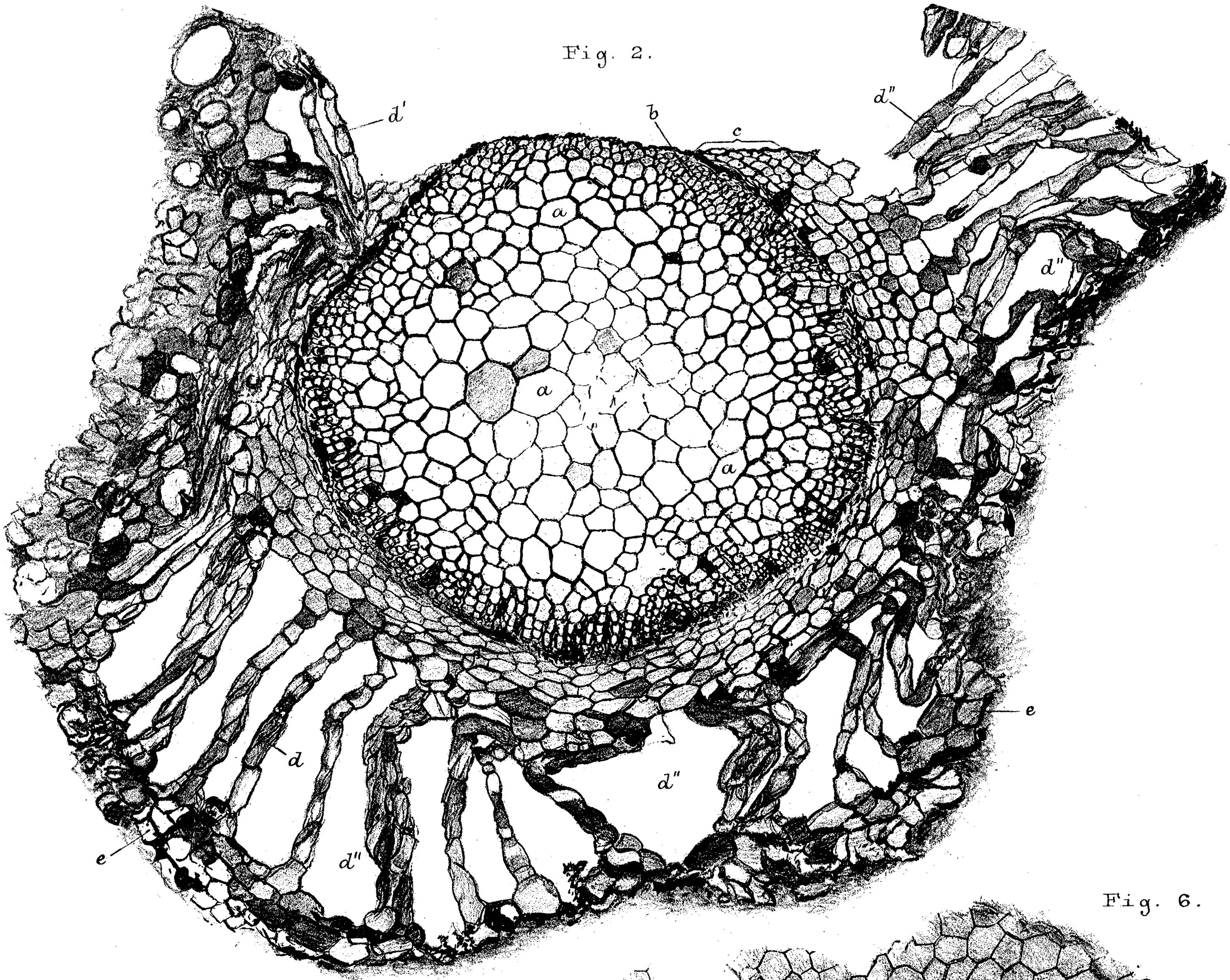

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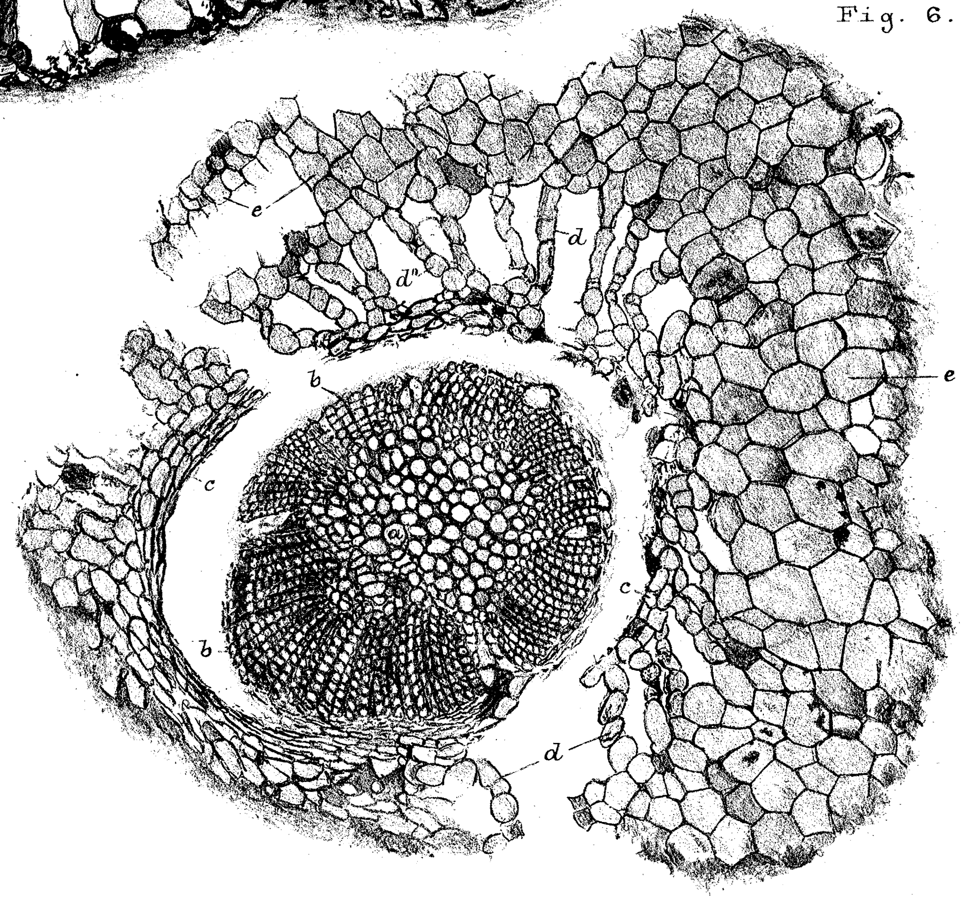

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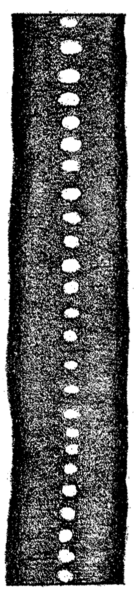

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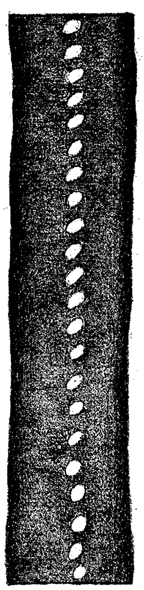

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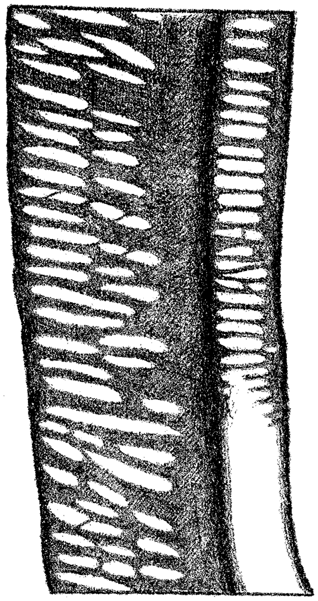

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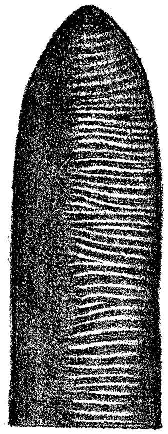

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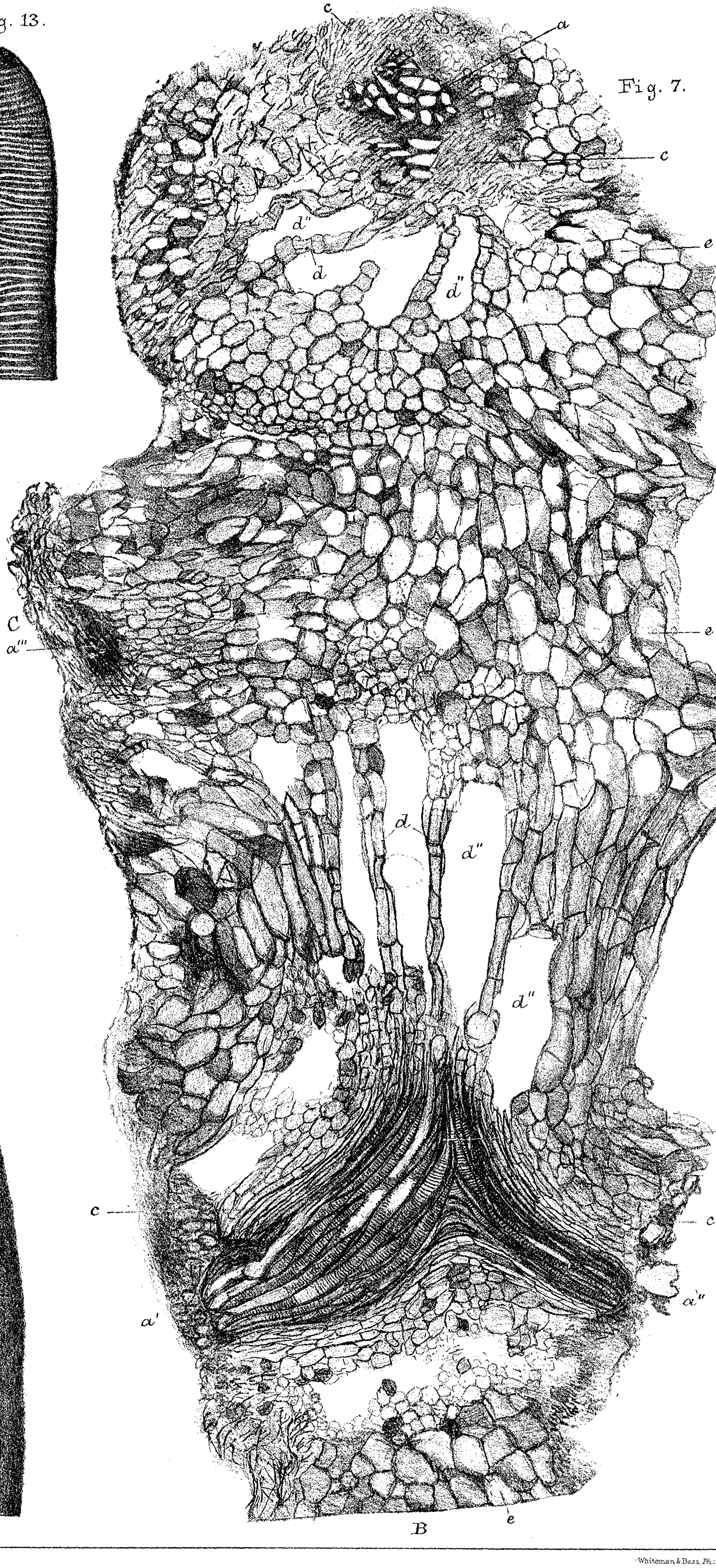

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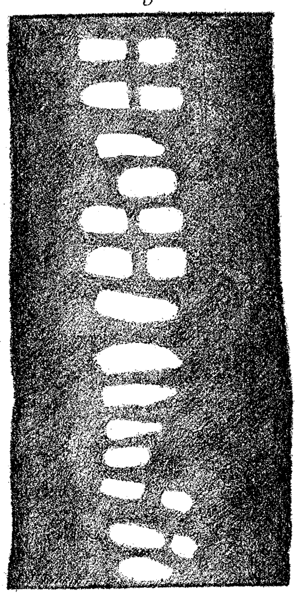

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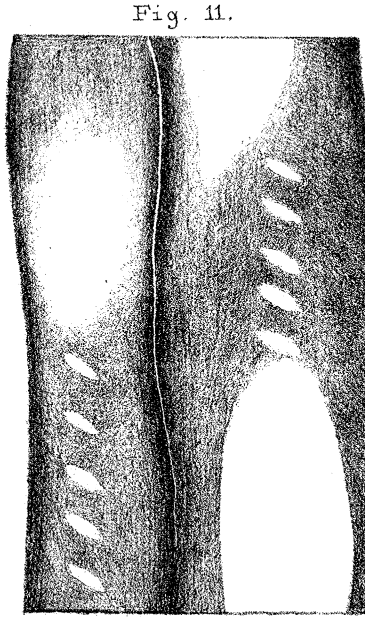

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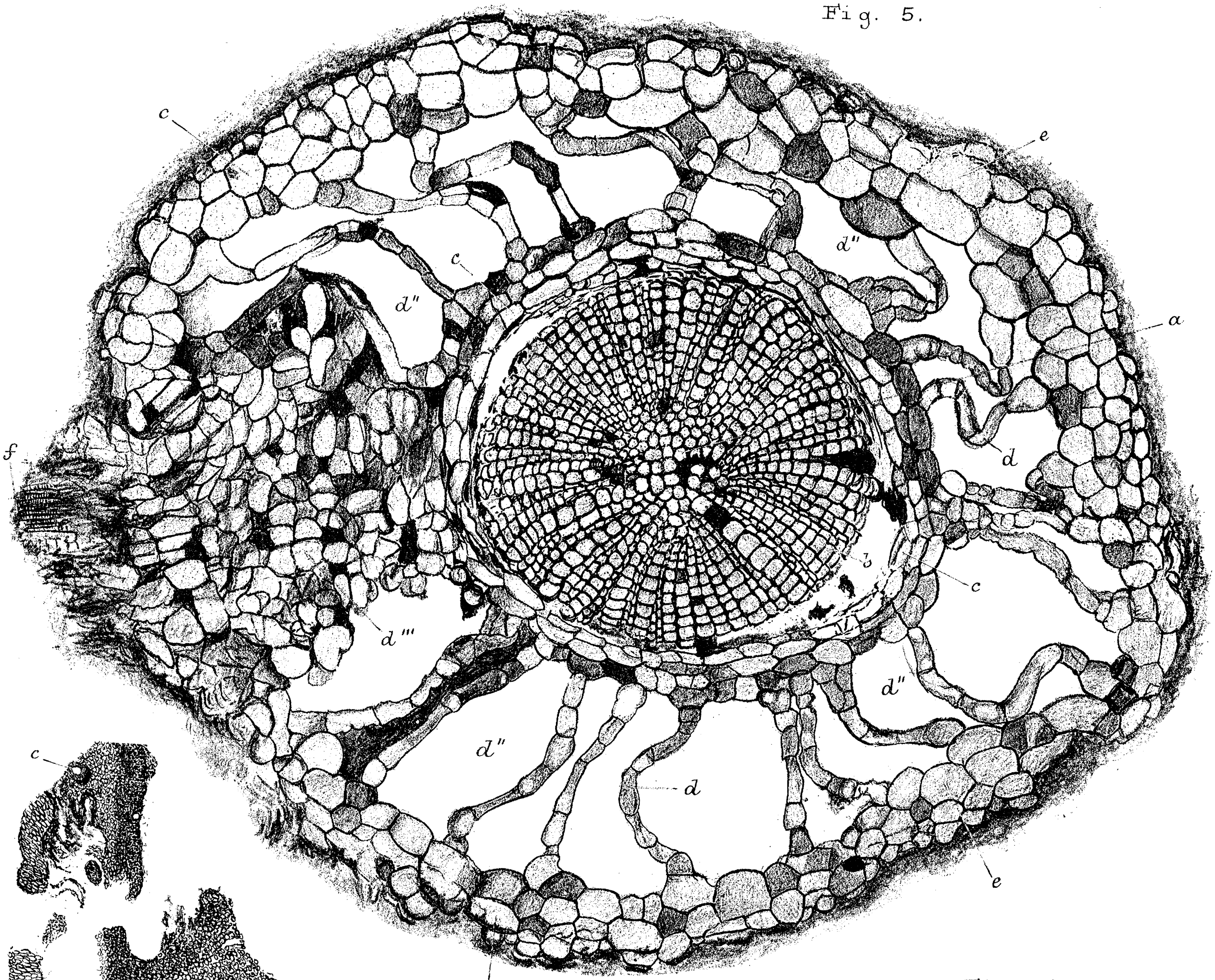

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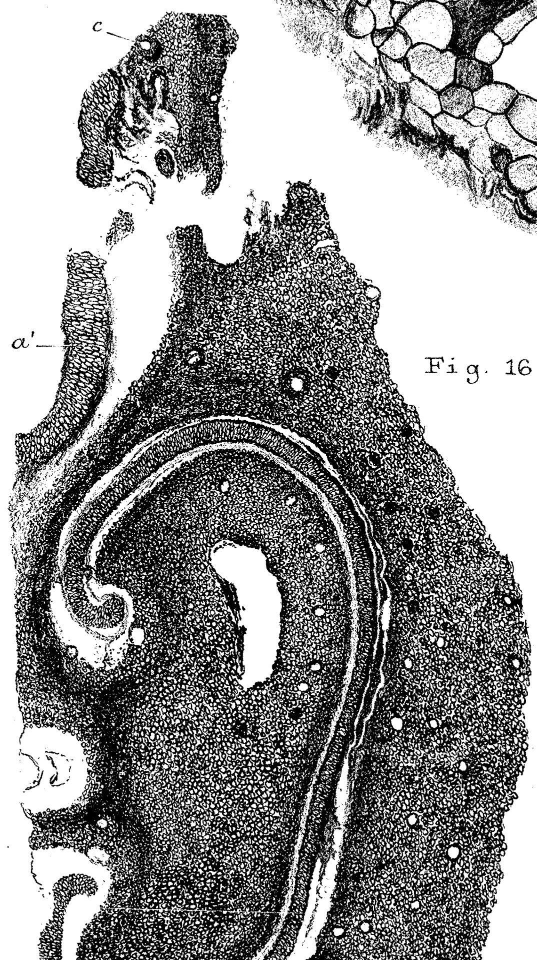

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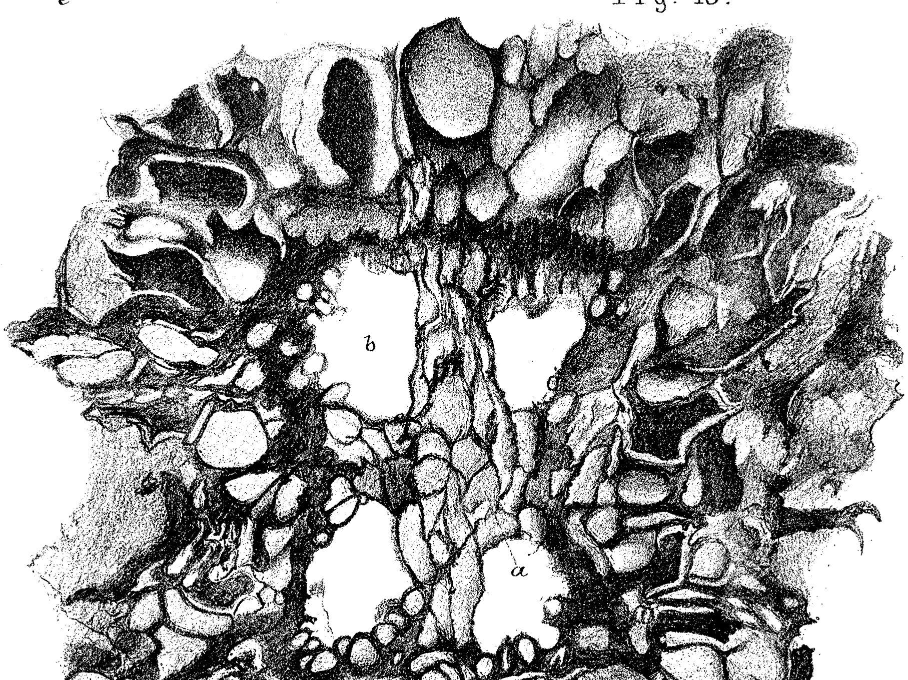

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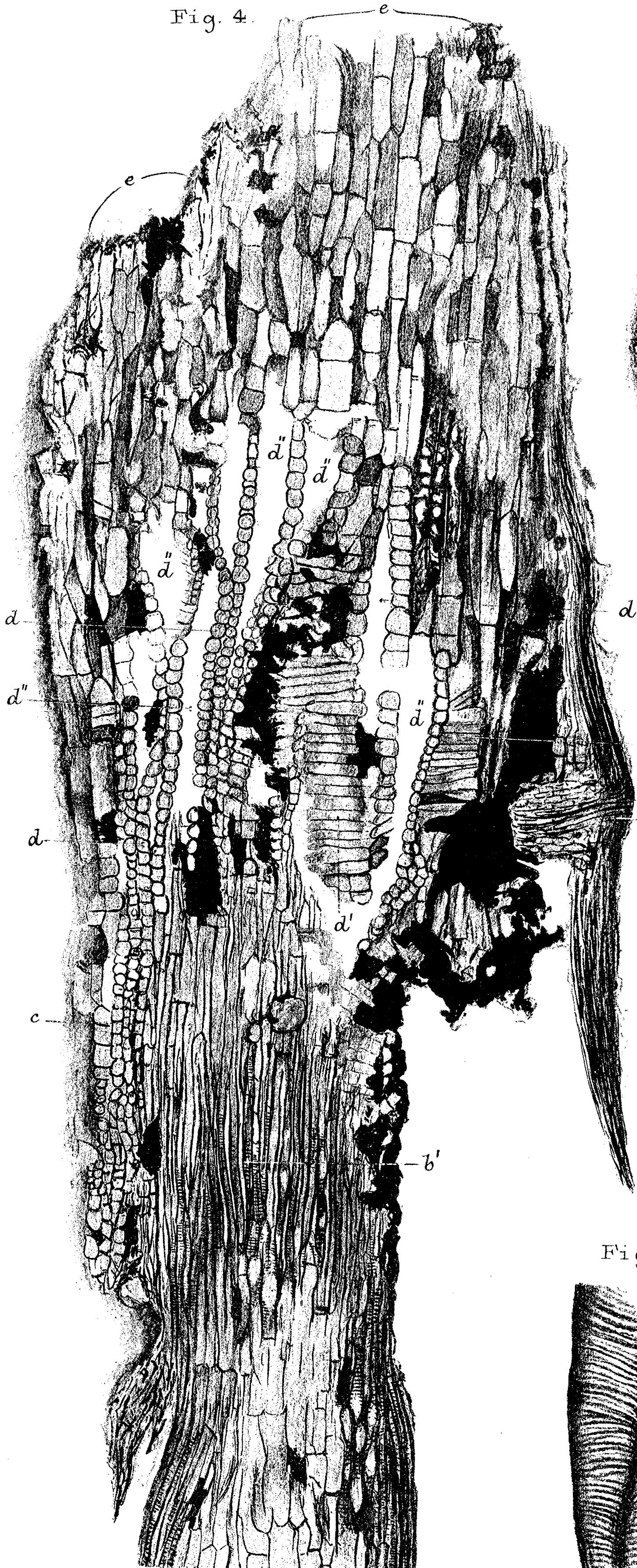

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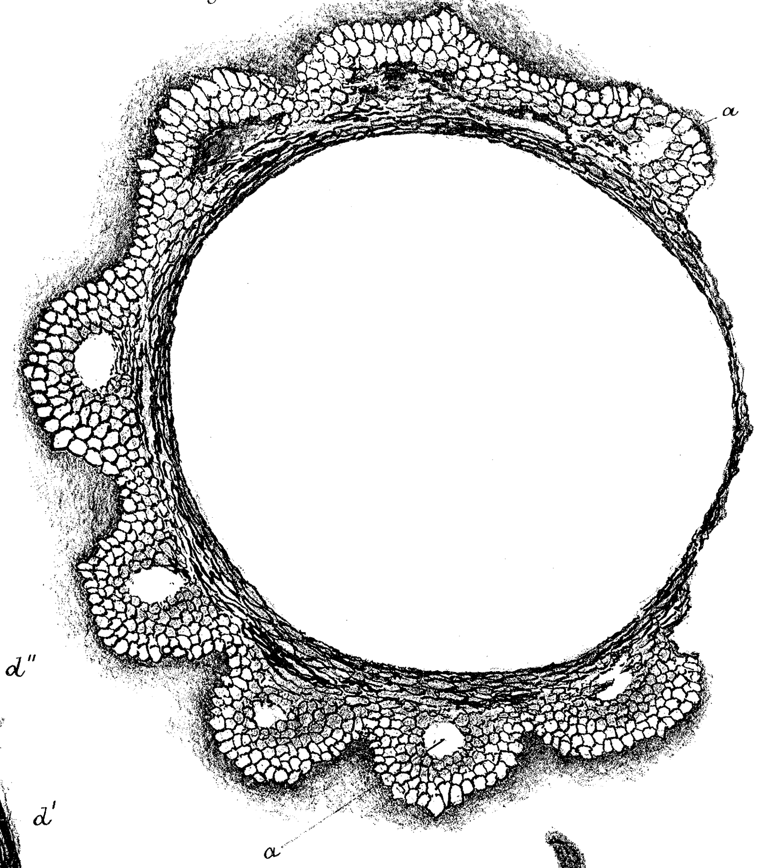

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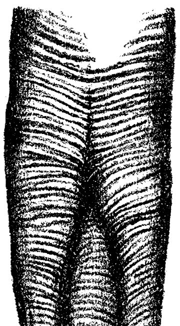

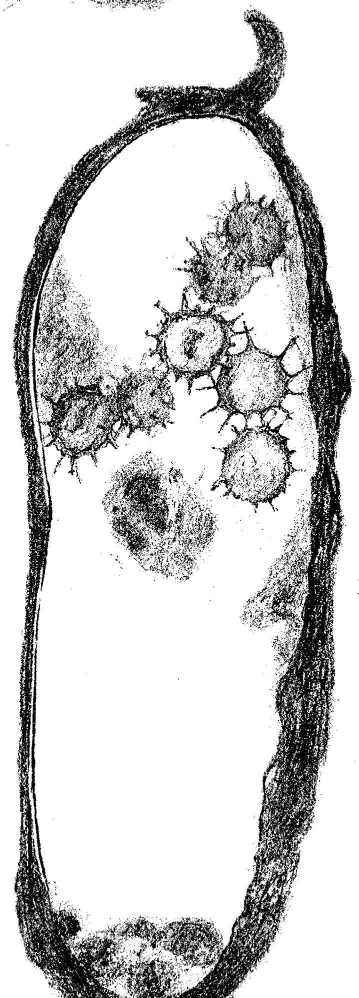

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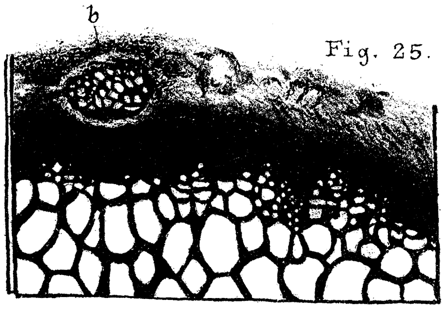

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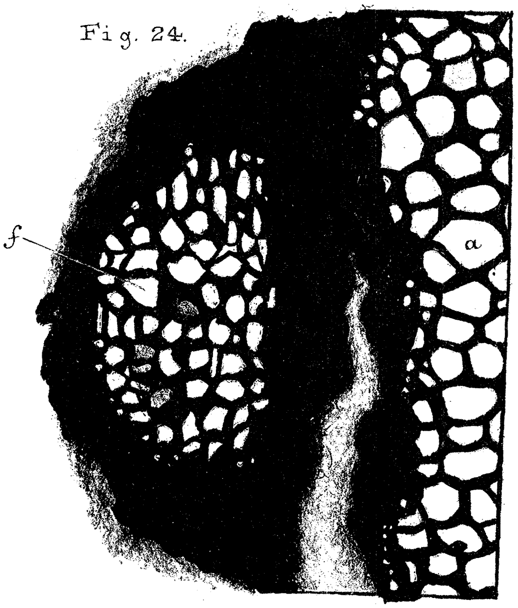

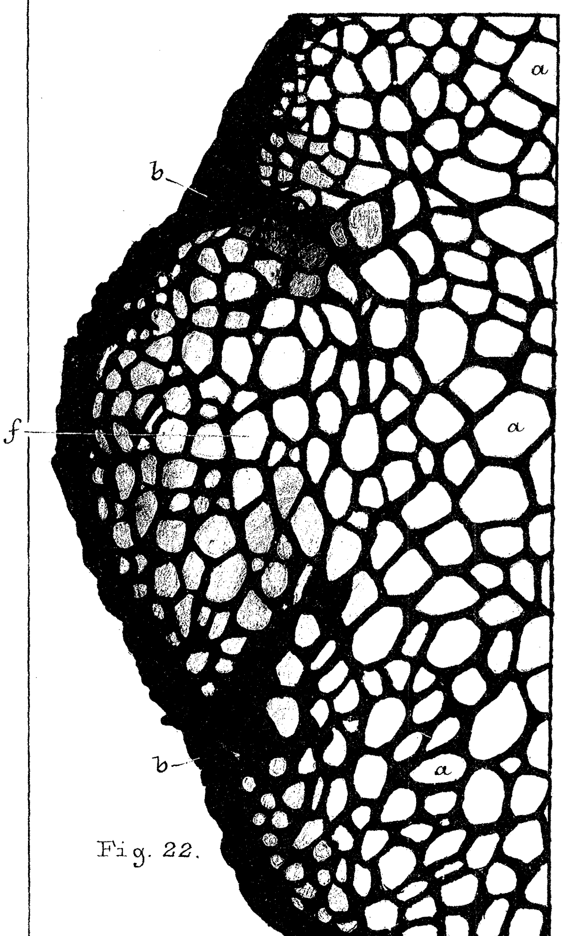

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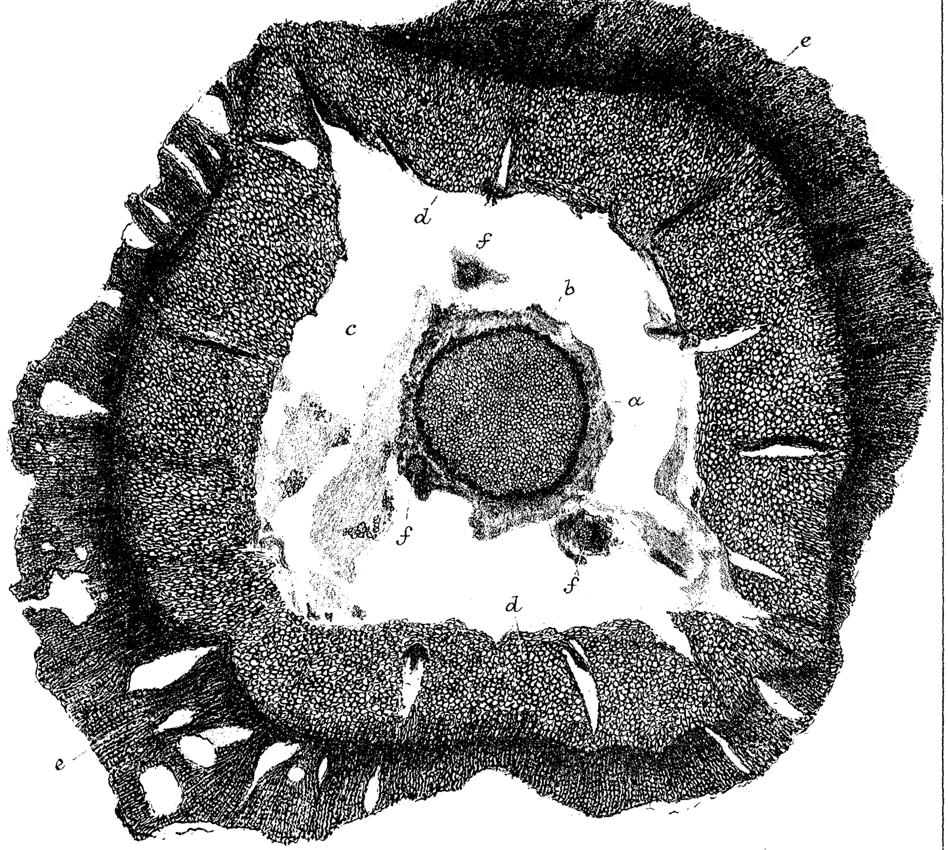

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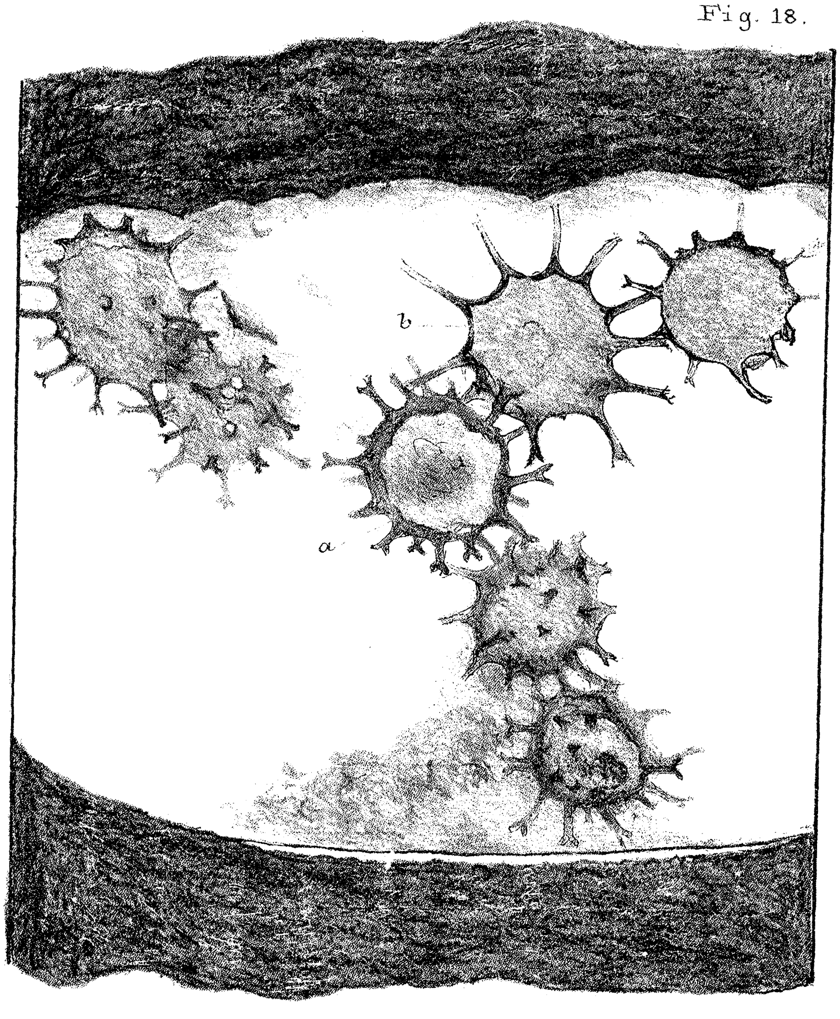

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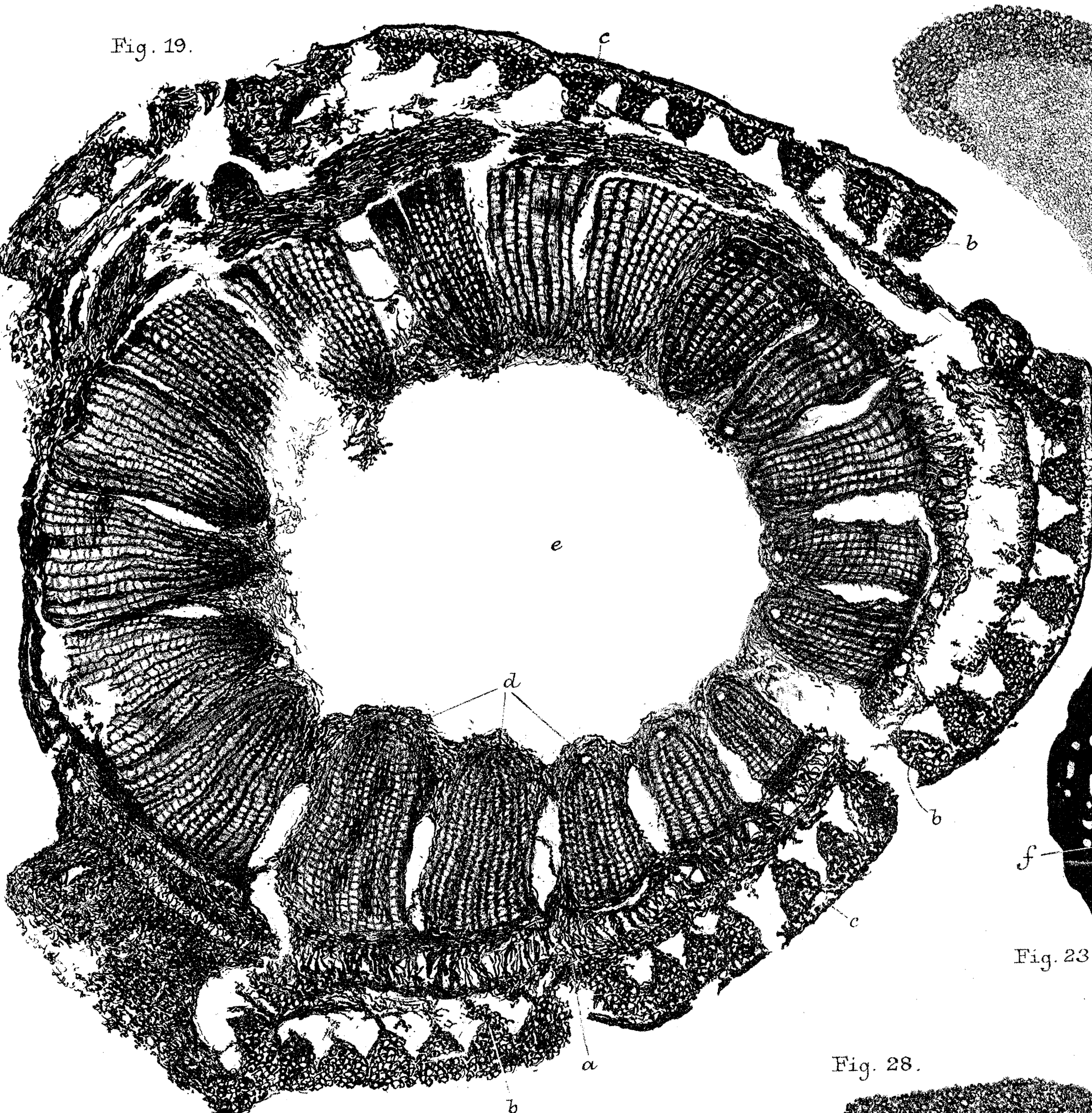

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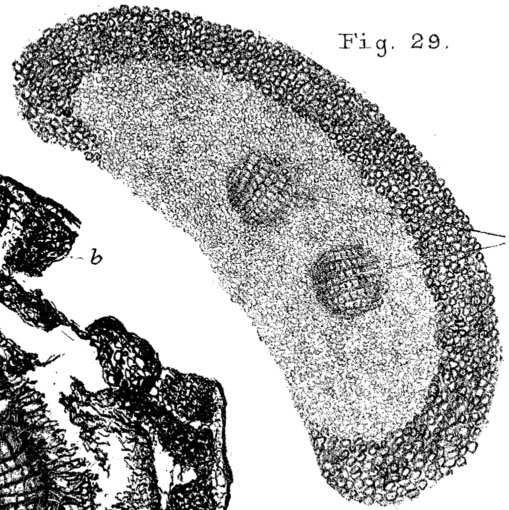

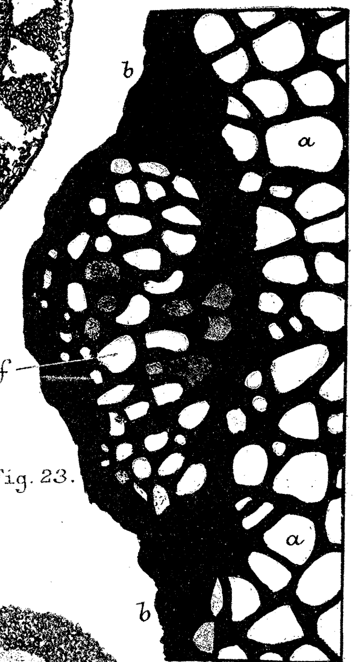

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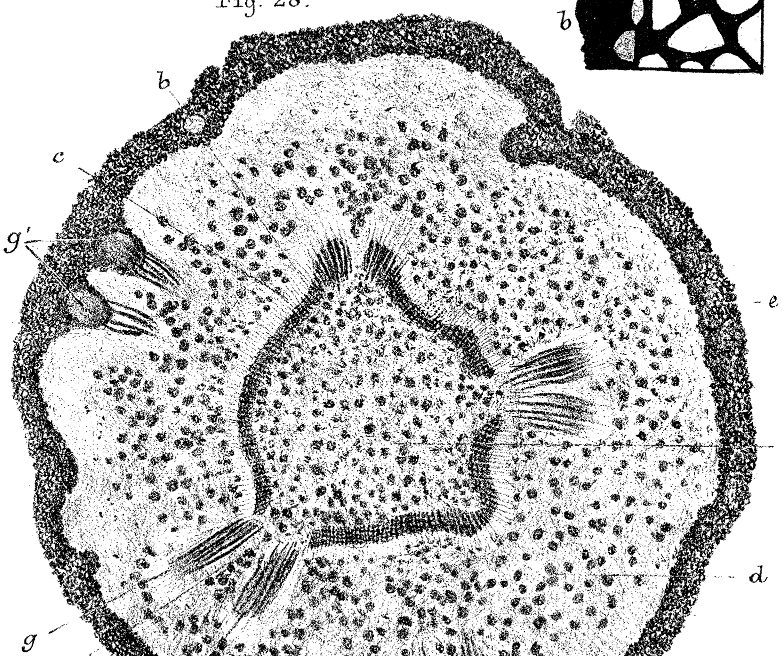

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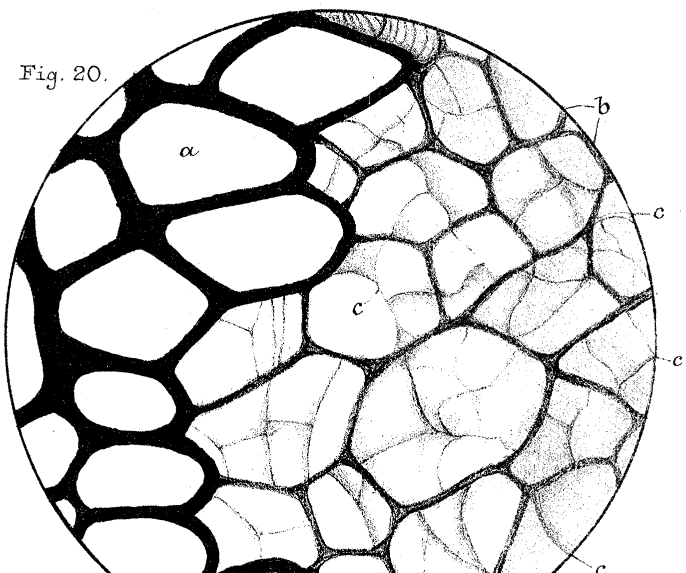

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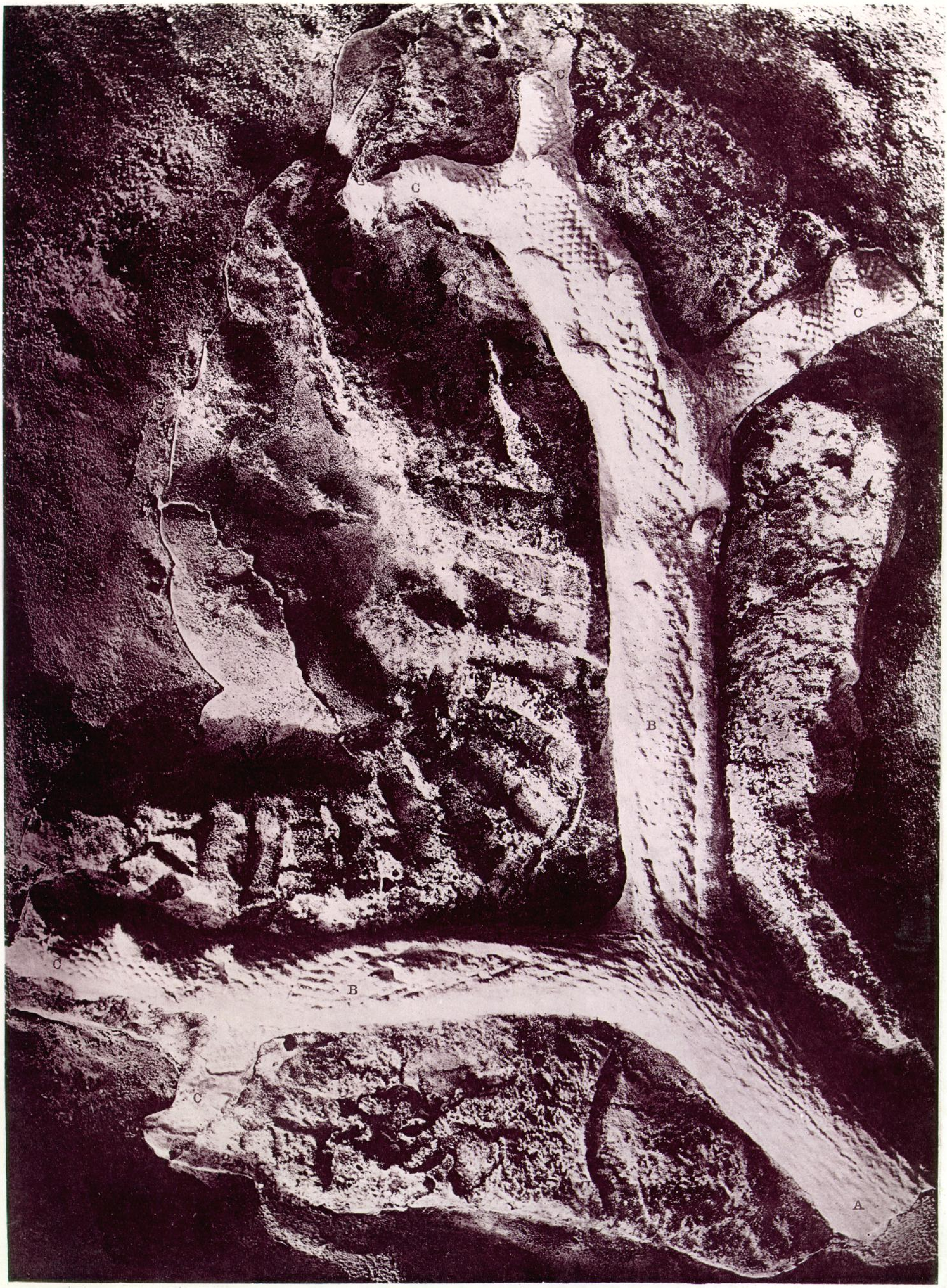

PLATE 34.

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