X. *On the Organization of the Fossil Plants of the Coal-Measures.*—Part IX.

By Professor W. C. Williamson, *F.R.S.*

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[Plates 19–25.]

In Part I. of this series of memoirs (Phil. Trans. 1871, Plate 25, fig. 16, and Plate 27, fig. 39, p. 487) I described what appeared to be a transverse section of a Calamite, in which the woody wedges showed no traces of the longitudinal canal that occupies the innermost angle of each of these primary wedges in true Calamites. Not having at that time the materials which I have since accumulated, I was unable to say much about this exceptional specimen. I now know that it is not a Calamite, but a plant having a wholly different structure, and to which I propose assigning the provisional name of Astromyelon, from the peculiar stellate form which transverse sections of its pith exhibit. The plant had branching, unarticulated stems, a feature which at once distinguishes it from the Calamites, though transverse sections of the two plants exhibit such remarkable resemblances. It is one of the more common of the forms met with in the Oldham nodules. I have rarely seen specimens of it more than 0·25* in diameter. One example alone, represented in fig. 5, has had a diameter of nearly 0·75. Fig. 1 represents the more usual aspect of transverse sections of this plant enlarged 20 diameters. It consists of a central parenchymatous medulla, *a*, surrounded by an exogenous cylinder of vessels arranged in a very regular series of primary wedges, *b*, corresponding closely in all respects with those of Calamites, except in the absence of the long canals already referred to. The central cells of the medulla are much larger than those of the circumference, some of the former having a diameter of ·011, whilst the peripheral ones are not more than ·0041. In the longitudinal section, fig. 2, *a*, and fig. 3, *a′*, these medullary cells are seen to be somewhat elongated vertically, being often ·022 in length. The cells have usually rectangular partitions, and are arranged in vertical rows, as in many living ferns; one or two of the rows in immediate contact with the vascular zone (fig. 3, *a′*) have a similar arrangement, though they are much narrower in their transverse diameter. In the great majority of cases the pith is solid. In but a few instances have I found it otherwise. Two of the latter are represented in figs. 4 and 5. Fig. 5 further

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* These measurements are, as in my preceding memoirs, made in parts of an inch.

presents an example in which the medulla has had an unusually great diameter in proportion to that of the vascular zone.

This exogenous zone is made up of a variable number of primary vascular wedges (figs. 1, *b*, 5, *b*), each one of which is composed of numerous radiating vascular laminæ separated by medullary rays. The remarkable uniformity in their size and the regularity in the arrangement of these wedges gives to the transverse sections of the medulla the star-shaped outline already referred to. At their inner or medullary apex each of these wedges commences at a few vessels of somewhat larger size than those composing the rest of the vascular zone. These are observable in fig. 1, but they are much more conspicuous in some examples than in others. Fig. 7 represents a section, for which I am indebted to Mr. BUTTERWORTH, in which these vessels are extremely conspicuous. The medulla of this specimen is much disorganized by mineralization, but it has not been fistular. Its diameter is much less than is usually the case, contrasting strongly in this respect with fig. 5. In Mr. BINNEY'S monograph on the Calamites* he figured, at page 20, what he believed to be part of a primary wedge of a Calamite, adding the remark, that in these Calamites "the wedge-shaped bundles of pseudo-vascular tissue originate from a small circular orifice or opening, sometimes simple, as in the specimen now under consideration, but in other instances apparently divided into several parts, as shown in the annexed woodcut (fig. 3)." I have no doubt that the latter examples were specimens of Astromyelon, which, like myself, Mr. BINNEY then mistook for Calamites.

The inner extremities of the primary woody wedges, where seen in transverse sections, have generally an obtusely convex outline rather than a sharply cuneate one. Fig. 5, however, represents an example in which they are much more wedge-shaped than usual, whilst in fig. 4, partly owing to the direction of the section, but yet more to a peculiarity in the specimen, the normal contour of these woody wedges is much less obvious than ordinary; still traces of their prevailing aspect are seen at the lower side of the base of the lateral branch *a'*. Each primary wedge is composed of a numerous series of laminæ, each one of which has a mean thickness of about ·002. The vessels of each lamina are arranged with the utmost regularity in a single radiating series, reminding us, so far as the transverse sections are concerned, of what we see in the woody prosenchyma of living Conifers. On making a tangential section we see that these vascular laminæ are separated by numerous medullary rays. Very frequently single laminæ are thus separated from each other. In other instances we see as many as three such laminæ unseparated by intervening rays. The vessels (fig. 6, *b*) rarely exhibit any special structure, but here and there, as at fig. 6, *b'*, we discover proofs that they were of the usual barred type, and that where the transverse bars are not visible their absence is merely a result of mineralization. The ordinary medullary rays (fig. 6, *c*) are arranged in single vertical series. The cells are elongated vertically and much compressed laterally. Occasionally a ray consists of a single

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* 'Observations on the Structure of the Fossil Plants found in the Carboniferous Strata,' 1868.

lenticular cell, whilst in others there are several cells arranged in a vertical series, the septa between these cells being square at right angles to their longer axes. The section represented in fig. 6 having been made at but a little distance from the medulla, we see at *c* one of the primary rays separating the primary wedges. It differs from the more numerous secondary ones in consisting of more than one vertical line of cells. As we approach the pith the number of such vertical series increases, whilst at the periphery these primary medullary rays become almost undistinguishable from the ordinary or secondary ones.

Notwithstanding the large number of specimens of this plant contained in my cabinet, I never succeeded in finding a solitary fragment in which the bark is preserved. Mr. BUTTERWORTH fortunately had better success. He met with the specimen represented in fig. 7. In this example the vascular zone is surrounded by a very thin layer of parenchyma (fig. 7, *d*), rarely displaying more than three or four cells in its thickness; more generally there are but two. The structure is obviously little more than an epidermal layer. At fig. 7, *d′* we have an indication of the loose way in which this layer was attached to the vascular zone, and which probably explains the excessive infrequency with which it is found in its normal position. This specimen further indicates the existence of concentric lines, suggestive of successive interruptions to the continuous growth of the vascular zone.

I have already observed that these stems were branched, such secondary branches ascending from the primary one at an oblique angle. In fig. 2 the section has intersected the base of one such branch in a very oblique manner. In the oblique transverse section, fig. 4, I endeavoured to incline the section so as to intersect the branch longitudinally. Though almost successful I was not completely so, since I did not quite trace the pith, *a′*, of the branch into connexion with that (*a*) of the main axis. It was sufficiently so, however, to demonstrate the continuity of the one with the other. In fig. 2 these medullary cells are intersected at *a′* near the base of the branch.

I have obtained no clue whatever to the plants to which these branches belonged. It is clear that structurally the individual woody wedges exhibit no difference whatever from those of a Calamite. Neither transverse nor tangential sections of the one can be distinguished from similar sections of the other. Their large primary medullary rays also exactly resemble those of Calamites. But the absence of articulations and the consequent absence of the alternation of the woody wedges in passing from one internode to another at once distinguish the two types. Further, the absence from Astromyelon of the remarkable internodal canals of Calamites, and also the difference in the medullary tissues of the two plants, constitute further distinctions between them. In Astromyelon the medulla was not fistular. The two exceptions, seen in figs. 4 and 5, are the only ones I have met with, and these may have been the result of desiccation rather than of a characteristic tendency to the formation of a fistular pith. That the growth of the vascular zone was exogenous is obvious enough. Though consisting wholly of barred vessels, the bundles are as open as in any other exogenous plant, yet we know of no gymnospermous stems that are entirely composed of such vessels, but which are so characteristic of the true carboniferous Cryptogams, hence I am inclined to place Astromyelon in the Cryptogamic group.

The plant just described is the only one belonging to a distinct type of vegetation left unnoticed in my previous memoirs. But since the earlier parts were published numerous objects have come under my observation throwing additional light upon several of the genera which I have previously described. These I now propose to examine in detail.

Calamites.

The wide-spread interest which these plants excite, and the continued existence of two sharply-defined and very discordant views respecting their nature and affinities, render further investigations necessary. Since my first memoir, which mainly treated of these objects, was published, I have gathered numerous additional illustrations of their history. The study of these specimens has only confirmed my previously expressed conclusion, that we possess but one type of these plants, and that the separation of Calamites from *Calamodendron* has no foundation in the facts of their organization. Fig. 8 is a transverse section of a small stem or twig not much more than ·033 in diameter. The medullary cells (*b*) are here unruptured, the medullary fistular cavity having as yet no existence. Nine longitudinal internodal canals are seen (*e*), and these form the only recognizable line of demarcation between the pith, *b*, and the bark, *h*. There is but little difference observable between the cells of these two structures.

Fig. 9 is obviously a decorticated specimen, similar in all other respects to fig. 8, but with eight canals, and the section has passed through the stem rather obliquely. In fig. 10 we have a transverse section through a similar stem or branch to fig. 8. We still discover the bark, *h*, the internodal canals, *e*, again nine in number, and the medullary parenchyma ; but the bark, in this example, is a thick layer of parenchyma of coarser tissue than that composing the medulla, and the latter now displays a central fissure, *a*, which obviously indicates the commencement of the formation of the medullary fistular cavity. We have still but very slight indications of the formation of woody wedges external to each of the internodal canals. Fig. 11 is a decorticated example in the same stage of development as fig. 10, only the medullary fistular cavity, *a*, is now of large size, and the internodal canals, *e*, are eighteen in number. Fig. 12, on the other hand, is another decorticated example in which the canals, *e*, are eleven in number, and the vascular wedges, *f*, are now advanced in development ; but the central fistular cavity, *a*, is in a stage of development intermediate between that of fig. 10 and fig. 11. In fig. 13, the original of which was found by Mr. BUTTERWORTH, the stem has attained to larger dimensions, being now about ·12 in diameter. The layer of medullary cells, *b*, is now extremely scanty, whilst the fistular cavity, *a*, is very large. In fact, the thin layer of medullary cells does little more than link together the large primary medullary rays, *c*, which separate the large vascular wedges, *f*. These wedges, each with its internodal canal, *e*, at its inner angle, are here thirteen in number. The cortical parenchyma is seen at *h*.

My cabinet contains other similar specimens besides those figured; the series clearly illustrates one type of structure seen in various degrees of development, and figs. 12 and 13 unmistakeably demonstrate the type to be identical with the *Calamodendron* of BRONGNIART and those who accept his views. We here see the gradual formation of the central fistular cavity, and of the vascular wedges, from a condition in fig 8, in which they exactly resemble what we find in living Equisetums, viz., canals with extremely few vessels at their outer border, to that of figs. 12 and 13, where exogenous additions have developed a well-formed wedge composed of numerous radiating laminæ of vessels separated by medullary rays. The structure of these wedges was fully described in my first memoir, and my recent researches require that nothing should either be added to or subtracted from those descriptions. It is obvious enough that if such examples as figs. 11 and 13 had been deposited horizontally, parallel to the stratification of a bed of shale, and subjected to vertical pressure, they would have become as flat, and almost as thin, as a piece of brown paper. In other words, they would have resembled the Calamites of BRONGNIART, and yet they are all true examples of the genus *Calamodendron* of that author.

We may now turn to the different conditions seen in figs. 14 and 15, which represent, two-thirds their natural size, transverse and vertical sections of a fine Calamite found near Oldham by Mr. NIELD. In the transverse section, fig. 14, the fistular cavity, *a*, has a mean diameter of about ·62. It is surrounded by an extremely scanty pith, *b*, which in turn is invested by a cylinder of vascular tissue fully 2 inches in thickness. At its inner surface this zone is divided into the usual radiating wedges, *f*, which have been either fifty-eight or fifty-nine in number. Each of these wedges starts internally from the characteristic canal, and they are separated from each other by the usual radiating extensions of the pith which I have always designated the primary medullary rays. These can easily be traced, extending outwards through the vascular cylinder as much as ·25, but beyond that distance the tissues become so blended together that the rays cease to be visible. In tangential sections made near to the pith these primary rays are very regular in form and arrangement, but long before reaching the middle distance between the pith and the bark they are only represented by a very small number of vertically elongated lenticular masses of cells, such as Mr. BINNEY has accurately represented in Plate iii., fig. 6, of his 'Monograph on Calamites and Calamodendron.' These cellular areas are arranged at very irregular intervals in all matured stems.

The aspect of the secondary rays in radial vertical sections is shown in fig. 16*d*. The vessels, *g*, are usually arranged vertically with great regularity, especially when seen in radial sections; but in one of my tangential sections there is an irregular vertical line varying from one-sixth to one-tenth of an inch in breadth, in which the vessels, instead of pursuing their regular course, are twisted and contorted, often dichotomising and interlacing in the most extraordinary manner, the irregular interspaces being occupied by expansions of the secondary medullary rays. As I described in my first memoir, this state of things is common enough in tangential sections where a branch is about to be given off, as in figs. 26 and 28; but I am wholly unable to explain its meaning here. Fig. 17 represents a small portion of the section referred to, in which *d* indicates the medullary rays and *g* the contorted vessels.

On turning to fig. 15, which is a vertical section made through the centre of the specimen, we find that the section has most fortunately passed through a node, the cellular extension of the medulla forming the nodal medullary diaphragm being seen at *n*. It will be observed that there is no nodal constriction at the exterior of the vascular cylinder, *f*, like that which is seen in the pith, and which forms so conspicuous a feature in the common sandstone casts of the medullary cavity. The most valuable, because, in my experience, unique feature of this specimen is seen in its bark, *h*. This is broken up into fragments, which, though often detached, and intermingled with Stigmarian rootlets that have penetrated between these fragments, nevertheless retain substantially their normal positions. A limited layer of parenchyma exists immediately external to the vascular cylinder, but the greater portion of the cortex consists of prismatic prosenchyma, the cells of which are arranged in regular radiating lines, an arrangement best seen in the transverse sections, as represented in fig. 18, which is enlarged 26 diameters. The cells have a transverse diameter of about ·0023. Their length varies greatly, but, as is the case with the cells of the primary and secondary medullary rays of the vascular zone, we find long radial lines of them having exactly the same length, each series terminating abruptly by coming in contact with other similar series composed of cells of a different but equally uniform length.

Tangential sections made through this tissue exhibit the appearance represented in fig. 20. The cells here have almost always the oblique or acute extremities of prosenchymatous tissue. Fig. 21 represents a small portion of a tangential section, enlarged 10 diameters, in which a lenticular mass of parenchyma appears. This tissue seems to me identical in character with the similar masses of cells seen in the vascular zone, and which, as I have already shown, are the outward prolongations of the primary medullary rays. It will be curious if future observations should prove that these cellular structures are prolonged through the prismatic layer of the bark to its periphery. Yet I strongly suspect that such has been the case.

I do not suppose that this layer of prismatic prosenchyma constitutes the outermost bark. The specimen when found by Mr. NIELD was worn and weathered, hence we have no means of knowing what was the entire thickness of the bark; the probability is that there would be an outer parenchyma in which the genetic line producing the prosenchyma would be found. This, however, is a mere probability which requires verifying. One thing is clear, viz., that the bark, as we see it in figs. 8, 10, and 13 is a primitive generalized parenchyma; but as the stems became arborescent, this generalized tissue developed within its interior the thick layer of prosenchyma which resembles so closely the cork layer of living Phanerogams. It will be remembered, however, that we find the same kind of tissue, in an almost identical position, in *Lepidodendron Harcourtii* as well as in all other Lepidodendroid and Sigillarian stems.

In my first memoir of this series (Phil. Trans., 1871, Plate 26, fig. 26; Plate 27, fig. 33, and Plate 28, fig. 38), I illustrated the general arrangement of the tissues at the node of the young Calamite. Since that memoir was published I have obtained some additional examples throwing light upon those curious structures. Plate 26, fig. 25, of that memoir represents a similar section to figs. 23 and 24 of the present one. In all these sections we see each of the vascular wedges of one internode (within which internode it is separated from its neighbours by the cellular primary medullary rays) subdivided into two portions, the half of one wedge uniting with the contiguous half of its next neighbour to form a new wedge in the next internode, whether above or below. I pointed out the existence at and near each node of two very distinct verticils, of objects. One of these verticils, situated immediately *upon* the node, appeared to me to represent bundles of specialised tissues going off to supply verticils of organs, probably small twigs or leaves. The second verticil instead of being planted *upon* the node occupied the uppermost portion of each internode. I showed that, in three distinct specimens, there existed at the uppermost extremity of each primary medullary ray a peculiar cylindrical or laterally compressed canal, from which all tissues had disappeared, and which was filled with the same inorganic material as that which occupied the fistular cavity of the pith. These passages I designated the infranodal canals. I further demonstrated, in fig. 22 and p. 490–91, that the areas which these canals occupied were originally filled with the cells of the primary medullary rays through which the canals subsequently passed. These cells became first ruptured, and secondly absorbed, leaving behind a verticil of sharply-defined canals arranged in a regular radiating order and passing to the periphery of the vascular zone. Some sections of a Calamite, for which I am indebted to Mr. BUTTERWORTH, exhibit these organs under a somewhat new aspect. In fig. 23 we have the vascular wedges at *f* and the primary medullary rays at *c*, *c′*, *c″*, the former exhibiting the nodal bifurcations to which I have just referred. We here see that at the nodal extremity, *l*, of each medullary ray of the lower internode, *c′*, *c′*, there is a small mass of cells of much smaller size than those which constitute the rest of the ray. These special cells occupy the centre of a lenticular enlargement of the end of the ray. It will also be observed that the lower extremity of each of the rays, *c″*, *c″*, of the upper internode the ray communicates by a very narrow neck with a small lenticular cellular organ, *m*, the central cells of which again are much smaller than those of its periphery. There is no question whatever that the small cells, *l*, *l*, of the lower row of rays occupy the exact position of my infranodal canals, whilst those terminating some of the upper series, c'', c'', indicated by *m*, appear to be identical with those similarly indicated in fig. 25 of my previous memoir on Calamites. It was perfectly clear to me when that memoir was written, that though the cellular structures, *l*, appeared to be but modifications of the primary medullary rays through which they pass, they nevertheless had some specialised character and function; and that their existence characterised the subgenus *Calamopitus* which I proposed to establish for the reception of the plants which exhibit these peculiar organs. Mr. BUTTERWORTH's sections, especially that represented in fig. 24, confirm these conclusions. I have already shown that in all Calamites, save very small ones, soon after leaving the medulla the primary medullary rays almost entirely disappear. They have done so in the present figure, in which their normal position in the upper internode is only indicated by the dark lines *c*, *c*. This section is also tangential, but more peripheral, from the same specimen as that which furnished fig. 23; but it will be observed that as the exterior of the stem has been much enlarged by exogenous growths, all the lenticular organs have also become much larger both in length and breadth than is the case in that figure. The remarkable feature revealed by this section is, that whilst all the primary medullary rays have disappeared, their lenticularly enlarged upper extremities, fig. 23, *l*, remain as the circumscribed lenticular areas, *l*, of fig. 24. These two figures being drawn to the same scale, *i.e.*, enlarged 8 diameters, a comparison of the organs, *l* of fig. 24, with the corresponding terminations, *l*, of the primary medullary rays, c' of fig 23, will show how much these organs, whatever their functions, have increased in size as they proceeded outwards. A radial section shows that they contain no traces of vessels. Fig. 25 represents one of these lenticular organs enlarged 25 diameters. The cells of its upper and lower extremities are large, like those of the primary medullary ray of which it is a remnant, whilst those of its centre are small. Their appearance is much the same in the radial section, only in it they are slightly elongated radially, *i.e.*, in the direction in which they are proceeding to reach the bark.

These facts, I think, show that I was perfectly accurate when in my memoir Part I., I assigned great importance to these organs. In that memoir I regarded the upper and smaller series, *m*, as supplying leaves or small twigs, believing that they contained vascular bundles. I am doubtful if I was correct on this point.* I believe that the transversely divided structures are chiefly cells, as already stated. In three cases I traced the development of the lower series, *l*, into verticils of the radiating infranodal canals, illustrated by fig. 31, which represents the lower extremity of the sandstone cast of the medullary cavity of a Calamite surrounded by the disorganised carbon, *f f*, of its vascular zone. The radiating spokes, *l*, are also sandstone casts of the interiors

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* Since this was written I have studied a vertical radial section of a Calamite sent to me by Mr. BINNS, of Halifax, in which some of the vessels ascending from below are, on reaching one of these lenticular organs, conspicuously deflected outwards, making it clear that *some* vessels do accompany these cellular radii in their outward course, confirming my original conclusion.

of the infranodal canals of one internode, whilst in *l'*, we have a few of the similar organs from the next inferior internode. The positions occupied by others which originally completed this second verticil are indicated by a ring of the small rounded scars so commonly seen on the ordinary Calamites (fig. 30, *l*). There can be no doubt whatever that these spokes represent the same parts of the plant as the lenticular cell masses, *l* of figs. 23 and 24. Why these organs continued to be occupied by cellular parenchyma in some specimens whilst in others the cellular tissues were absorbed when the medullary cells underwent the same fate, the former being thus converted into radiating prolongations of the medullary fistular cavity thus produced, I cannot determine. The most probable solution is that the two conditions represent different species of plants, in some of which the cellular elements of the radii had but a transitional temporary use, whilst their function was more permanent in others.

Some further light is thrown upon these anomalous structures by the specimens represented in figs. 26 and 27. These are sections of a large Calamite found by Mr. BUTTERWORTH, the surface of the node of which exhibited a few deep circular depressions, that appeared to have been points from which branches had been detached.

A transverse section of the structure underlying one of these depressions is represented in fig. 26, and a vertical one in fig. 27, both figures being enlarged five times. Fig. 26 is a tangential section of the vascular zone of the primary stem, the vessels of which are seen at *g, g,* separated by their numerous accompanying secondary medullary rays. These vessels are deflected right and left to allow of the exit of a cylindrical mass of parenchyma in which numerous vessels meander in a tortuous manner, especially at the upper and lower margins of the cellular area. The diameter of this cellular mass is about ·25. Fig. 27 is a radial section through a portion of the same Calamite in which a similar branch is again intersected. At *a* we have part of the medullary fistular cavity, and at *b* a few of the true medullary cells; at *g, g* we have the vessels of the vascular zone, which, it will be observed, bend outwards from the medulla, both above and below the incipient branch, forming arches across the node, in the way which I have previously described as characteristic of their nodal arrangement. At *g', g'* the vessels are intersected more or less transversely because of their lateral deflexion to pass round the cylindrical branch, *m*. At its inner extremity, *m'*, this cellular outgrowth from the medulla is only about ·033 in diameter, but it increases rapidly in size as it proceeds outwards, until, at a distance of ·16 from the point at which it enters the vascular zone, it becomes, like fig. 26, enlarged to ·25 in diameter. It will be noticed that whilst numerous vessels meander amongst the cells of the periphery of the central branch of fig. 26, there is no approach to a radiating arrangement of these vessels, or to the formation of a distinct vascular cylinder. It is otherwise with fig. 28, which represents a similar section to fig. 26, enlarged 30 diameters, from a decorticated Calamite in my cabinet, the diameter of which stem is about 1·25, and the thickness of its vascular cylinder averages about ·25. The primary medullary rays are seen at *c*, and the intervening primary vascular wedges at *f.* At *m* we have a verticil of small lenticular cellular areas resembling fig. 23, *m*, and in the centre of the figure is a large circular area representing a branch. In this latter structure we have a medulla composed of parenchyma, the central cells of which are larger than the peripheral ones. This medulla is encompassed by a vascular zone composed of laminæ of vessels arranged in slightly curved radiating lines, and which are, beyond all question, derived from the surrounding vascular tissues of the parent stem. The continuity between the longitudinally intersected vessels of the latter, and the transversely divided ones of the branch, is clear and unmistakeable. We further see that the latter evince an equally obvious disposition to arrange themselves in numerous small radiating vascular wedges, but which exhibit no trace of the large internodal canals invariably found at the inner extremities of the wedges of true Calamitean stems. I am not certain that these incipient wedges are identical with the very regular primary vascular wedges seen in ordinary Calamites, but they are obviously preparing to assume that condition.

The stem which furnished the last section also supplied me with some others. One of these made near the periphery of the vascular zone corresponded very closely with fig. 26. On making a second section parallel with the first one, but nearer to the medulla, I obtained the result seen in fig. 29. I think there is no room for doubting that the lenticular area, *m*, is the representative of the similar areas indicated by the same letter in fig. 23, and that it has been the virtual starting point of the young branch ; but we further find some enlarged secondary medullary rays, *m′*, *m′*, which may have contributed towards the cellular elements forming the pith of the young growth. This section seems to prove that, as in the higher exogens, a connexion is maintained between the medulla of the central stem and that of its branches through the intermediate agency of its enlarged medullary rays.

I think we can have no hesitation in concluding that in the organs just described we have the beginnings of peripheral branches before they have emerged from the parent stem, and that the specimen shown in fig. 38 of Part I. of these memoirs was, as I there suggested, a similar organ. It appears to me further obvious that the organs which I there designated infranodal canals, but which it now appears sometimes retain their primitive cellular tissues instead of their becoming absorbed, must have fulfilled some important function, since, though the large *primary* medullary rays, in which these organs originate, contract their dimensions as they proceed outwards until they become virtually merged in the inconspicuous secondary medullary rays of the woody wedges, these radial organs not only do *not* thus disappear, but actually become larger, and their boundaries become more clearly defined as they proceed outwards through the vascular zone towards the bark. This circumstance explains the great definiteness with which we discover the circular and oblong scars marking the position of these radii, even in the ordinary specimens of Calamites found imbedded in the coal-shales.

But we still remain encompassed by physiological and morphological difficulties. Thus we have seen that as the rudimentary branches pass outwards through the vascular zone they carry along with them many of the vessels of that zone, arranged as shown in fig. 28. But in none of these branches thus enclosed within the primary stem do we see any development of nodes with their peculiar vascular arrangements or of the longitudinal internodal canals. Are there two sets of branches, one with and the other devoid of these characteristic peculiarities? Such is very unlikely to be the case. Do the vascular elements of the branch of fig. 28 re-arrange themselves into the characteristic Calamitean form *after* they emerge from the parent stem? The curious "Phragmata" existing in the closest connexion with the grooved, sandstone, medullary casts of the common specimens of Calamites seem to indicate the contrary, and to show that the peculiar conditions which occasioned the grooved contours of the medullary casts of the parent stem, existed equally in the branches where the latter were in close contact with the parent medulla. Then, again, what are the examples represented in figs. 8, 9, and 10 of this memoir, in which we have states whose size indicates even a much earlier degree of development than is seen even in the branch of fig. 28? In them the formation of the longitudinal canals clearly *precedes* that of the vascular structures; a stage of growth in which they closely resemble the living *Equisetum;* whereas, in fig. 28, we have a considerable development of the vascular tissues, but, as yet, no canals. My own impression is that, minute as many of the examples represented by such figs. as 8, 9, 10, 12, and 13 are, they are young plants directly developed from spores; and that in their half-embryonic state they represent *temporarily* the permanent condition seen in the more degraded Equiseta of the present day.

Fig. 30 is a suggestive example of a Calamite in blue shale from the Upper Coal-measures of the Manchester district. It is in the cabinet of Mr. DRINKWATER, formerly of Manchester, but now resident in the United States of America. It is obviously one of those examples which some of my friends would regard as not being a *Calamodendron,* but a Calamite of the supposed Equisetaceous type of *C. Cistii* and *cannæformis.*

According to my hypothesis, a is the inorganic cast of the interior of the medullary fistular cavity of a primary stem, and a' is a similar cast, only belonging to a lateral branch. The former organic connexion of the two is shown by the carbonised area, f, which I have no doubt is a relic of the thick vascular layer with which the pith was originally invested. The large medullary cavity of the branch a' appears as if it had not reached the corresponding cavity, a, of the central stem, but terminated at a'', or fully a $\frac{1}{4}$ inch from it. If this was the case this specimen would seem to indicate that the characteristic Calamitean features of a fistular cavity, viz., of distinct nodes, longitudinal grooves and the verticils of scars marking the position of the infranodal passages, began to appear in very young branches, not at the medullary surface of the vascular cylinder of the parent stem, as the phragmata already referred to seem to suggest, but at some distance from that surface; in which case the connexion between the two medullæ, *i.e.*, of the stem and of its branch, might be maintained by means of such cellular structures as those seen in fig. 27. If this has been the case then the possibility which I have suggested would become an established fact, viz., that so long as the *young* branch was passing outwards through the vascular zone of the parent axis, it did *not* acquire those features which we have seen to be so remarkably characteristic of Calamitean organization, but that when they did completely emerge from the stem those features appeared, at first in a very moderate degree, but soon undergoing rapid development both as to definiteness and size. It is impossible to believe that the large branch of fig. 30 was connected with its parent stem only by the tip of the small mamilla, *a″*, constituting its inner extremity. There must have been a large amount of tissue of some kind uniting the two firmly together, but which tissues have disappeared during mineralization—the only trace left of the former existence of that tissue being the dark stain, *f*, which still connects the stem and branch, and which demonstrates that their union is organic and not accidental; whether the stem and branch still continue at the same distance apart from each other that they held when living may be questioned--but all the numerous facts which we now possess show that a branch possessing a medullary fistular cavity of the dimensions seen in the specimen under consideration, must have possessed a vascular cylinder of considerable thickness to sustain its weight, even when we have made all necessary allowance for specific variations in the relative dimensions of these two parts in such plants.

Since writing the above descriptions, I received from Mr. ISAAC EARNSHAW a specimen which, on being cut into, revealed important evidence bearing upon the question of the branching of Calamites. A transverse section of part of the specimen is represented, two-thirds of the natural size, in fig. 31B, and a longitudinal section is shown in fig. 31A. At 31B, *a* is the medullary cavity of the parent stem, whilst at *a′* of the same figure we have the similar cavity of a lateral branch, *m*. The vertical section, fig. 31A, shows that the branch, *a′*, is given off from the stem, *a*, nearly at right angles to the latter; we here learn many truths: 1st, that the medulla of the smaller branch is fully as large as that of the parent stem, as is the case in the specimen fig. 30; 2nd, that the woody wedges, with their large primary medullary rays, are equally developed in both; 3rd, that only the outer and newer exogenous vascular layers of the parent stem extend over and form the vascular zone of the branch; 4th, at *i*, *i*, we have the two sides of a node of the parent stem—being that from which the branch obviously originated—and at *i′*, *i′*, we have the next superior node of the same axis. On the branch I discover no trace of a similar node. These two sections clearly prove, beyond possibility of further doubt, that whatever may have been the condition of the lateral branches in their very young state, such branches as did not fall off or become abortive, gradually became invested by the successive woody layers that were added to the parent axis subsequently to the first appearance of such branches. The two grew together, and thus the relations of stem and branch became exactly the same as those observable in any ordinary exogenous tree. It thus becomes evident that the correctness of my argument in favour of my opinion, viz., that the medullary casts of both the stem and branch of fig. 30 were once enclosed within a *thick* woody zone, but which has disappeared during mineralization, is amply confirmed, and that when, in our imaginary restorations of the mature Calamite, we give to it a straight substantial stem with verticils of extremely slender twigs we make a mistake. That such was the case with very young stems is more than probable; but my specimens seem to show that many of the twigs of each verticil were arrested at an early stage of their development, whilst the few that were not so arrested did not differ materially in their external appearance from the branches of an ordinary Pinus.

I presume that these facts will, at the first glance, give seeming support to those who still believe in a group of gymnospermous Calamodendra, but I cannot accept this inference.

It is to me a surprising fact that there can be palæo-botanists who still believe in the existence of Equisetaceous Calamites apart from gymnospermous Calamodendra. Oldham, Halifax, and Autun, have now supplied immense numbers of stems of all sizes, from the delicate shoot represented in my figure 8, to the large arborescent stem shown in figs. 14 and 15. How is it that we nowhere find a solitary fragment which can be identified with the Calamites of BRONGNIART and M. GRAND-'EURY? Even the latter author is obliged to admit: "Il est au moins surprenant qu'on n'ait pas mit le main sur un Calamite avec la structure conservée."* There can have been nothing in the structure of an Equisetaceous plant to prevent its conservation equally with the delicate rootlets of the Stigmariæ which are so abundant in our carboniferous nodules. The supposed Calamites have been too abundant for the absence of the required specimens to be explained on the ground of rarity; yet where are they? I marvel that this fact alone does not satisfy my friendly opponents on this question, that Calamites and Calamodendra are identical plants. But this is not all; M. GRAND-'EURY speaking of Calamodendra further admits: "Le bois est formé par l'alternance des lames rayonnantes de tissus différents, cancrelé par suite de cette composition, articulé par l'arrêt et le croissement des lames aux articulations, qui, étant en outre accompagnées de cicatrices raméales, *donnent lieu, sur le surface, à une véritable forme de Calamite.*" The italics of the last noteworthy observation are mine. The statement thus emphasised is not only true, but even more thoroughly so than the above sentence indicates. In addition to the perfect identity, in the two cases, of the arrangement of the vertical lines of alternating vascular and cellular laminæ, and their change of relative position at each node, there are yet further resemblances to be noted. We have seen that at the nodes of my plants, which M. BRONGNIART regarded, and M. GRAND-'EURY still regards, as Calamodendra, there exists the two verticils of lenticular areas seen in fig. 24, and one of which verticils we have further found to be identical in position and origin with the infranodal canals represented by the elongated

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* 'Flore Carbonifère du Département de la Loire et du centre de la France,' par F. CYRILLE GRAND-'EURY. Mémoires présentées par divers savants à l'Académie des Sciences de l'Institut de France, 1877. Première partie, Botanique, p. 30.

spokes of fig. 31. Whatever these latter objects may have been, they are very remarkable and uncommon appendages to a vegetable stem. They coexisted with a thick vascular Calamodendroid zone, and it is their medullary extremities that are represented by the scars, *l*, of fig. 30; even when that vascular zone has disappeared, and nothing remains but the inorganic cast of the medullary cavity, these scars also remain, indicating the former existence of the canals to which they owe their origin. Both these verticils of nodal appendages are discoverable in most of the objects recognised as Calamites by BRONGNIART, GRAND-'EURY, and those who agree with the French school of palæo-phytologists on this point. Yet I am asked to believe that these extraordinary combinations of detailed structural resemblances are to be found in two classes of plants so remote from each other as are the Cryptogamic Equisetaceæ and the Gymnosperms. Surely such an instance of mimicry as this would, if true, be far more remarkable than any of Mr. WALLACE's illustrations of that curious phenomenon. But I am convinced that it is not true, and still hold that all the suppositious distinctions upon which M. GRAND-'EURY relies in his recent volume, for separating Calamites from Calamodendra are fallacious ones, and that they are altogether outweighed by the structural identities to which I now once more call attention.

Asterophyllites.

The next specimen to be noticed is one throwing additional light upon some described in my fifth memoir as belonging to the genus *Asterophyllites.* It will be remembered that M. RENAULT described certain stems which he regarded as those of *Sphenophyllum,* and he was doubtless justified in doing so. In the memoir referred to I showed that numerous stems which I believed to be those of *Asteropyllites* had, typically, the same structure as those of *Sphenophyllum.* In his recent work on the coal-measures and coal-plants of central France, my friend M. GRAND 'EURY disputes the correctness of my determination. He says, "Il est donc, en tout cas, bien certain que nous avons à faire à la structure des tiges de *Sphénophyllum,* et non à celle des *Astérophyllites,* comme M. WILLIAMSON le prétend, d'après des exemplaires calcifiés munis de feuilles plus nombreuses, apparemment simples; mais le Bechěra grandis paraît se rapporter à quelque *Sphénophyllum,* et je connais des tiges de *Sphénophyllum angustifolium* avec de nombreuses feuilles aciculaires à peine soudées légèrement deux à deux à la base."* In my memoir, Part V., pp. 48, 49, I calculated that the plants there described must have had about 24 long linear leaves in each verticil, and I further pointed out that the transverse sections of these leaves (*loc. cit.,* Plate III., figs. 14, 17) displayed a central thickening, indicative of the existence of a single midrib to each leaf. The specimen which I now figure, fig. 32, is a transverse section of the same stem as that represented in fig. 2 of Part V. of my memoirs, but that figure merely represented a section of an internode. The section now published has passed *obliquely* through a

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* 'Flore Carbonifère Botanique,' p. 50.

node, intersecting at once both some leaves and the commencement of a branch. The characteristic primary vascular, triangular, axis of the stem is seen at *c*, enclosed within a single exogenous series of vessels, *d*, as described in my previous memoir. The inner bark, *g*, has disappeared, but the outer bark, *k*, remains perfect. In the section previously figured the outline of the bark exhibited the three deep internodal furrows so common amongst these plants, but in the section now described these internodal furrows are, as is usual at the nodes, not present. On the lower margin of the figure we see in the outer bark the row of circular areolæ, *l*, *l*, which are obviously points from which a corresponding number of vascular bundles have disappeared. At *l′* we find one of these circular areolæ exactly opposite the base of the leaf *m*, and at *l″* we find that the next similar areola is intersected more in the direction of its length and is actually being prolonged into the centre of the leaf *m′*. There can be no doubt whatever that these areolæ represent a corresponding number of primary vascular leaf-bundles, and that there was but *one* of these bundles to each leaf. That the objects *m*, *m′* are leaves and not branches is fortunately demonstrated by the fact that at *x* we have a small triangular bundle of the usual characteristic shape, which is obviously going off to supply a true branch. Since there are nine of the leaf-bundles in the left half of the section it is obvious that had that section also passed exactly through the node on the right hand side of the specimen, we should have had at least eighteen of these vascular bundles going off to a corresponding number of leaves.

In determining whether this specimen is an *Asterophyllites* or a *Sphenophyllum*, we must understand what the distinctive features of these two genera are. BRONGNIART defines *Sphenophyllum* thus:—“Feuilles verticillées, cunéiformes, tronquées, entières ou dentées, émarginées ou profondément dichotomes, quadrilobées à lobes plus ou moins profonds et grêles.”[*] He adds that “dans quelques espèces, les lobes deviennent profonds, étroits et linéaires, et peuveut être pris pour autant de feuilles distinctes analogues à celles des *Astérophyllites* avec lesquelles il est alors facile de les confondre,” and again he remarks, “il faille une grande attention pour ne pas le confondre avec certaines espèces *d’Astérophyllites.* Il se rapproche, en effet, de ces plantes par la disposition verticillaire de ses feuilles, mais il en diffère par le nombre beaucoup moindre de ces organes à chaque verticille, 6 à 8 ou 10, et par leur forme qui est triangulaire, tronquée au sommet, ou dentés et lobés quelquefois très profondément.” Now, the leaves of my plants exhibit none of these features, being long, linear, and entire, and from eighteen to twenty-four in each verticil. It is impossible to look at the two leaves *m* and *m′* of fig. 27 without seeing that they show no signs of becoming cuneiform. Still less can we examine those described in my memoir, Part V., and figured in Plate 3, examples of which I made sections in every possible direction, without arriving at the same conclusion. Messrs.

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[*] ‘Tableau des Genres de Végétaux Fossiles,’ p. 52.

Coemans and Kickx, in their 'Monographie des Sphenophyllums d'Europe,'* define these plants as "foliis cuneatis, sessilibus, verticillatis, *nervo medio destitutis,* nervulis autem æqualibus, dichotomis." Here again we have an obvious distinction between a clear definition and my plants. The circle of areolæ in my fig. 27 clearly mark the positions of a verticil of median leaf bundles, whilst the leaves *m* and *m'* in that figure as clearly show that but one such leaf-bundle went to each leaf, hence we have here no dichotomization. Had these nervures branched we should have found that of 24, *m'*, doing so long before it had advanced so far into the leaf. Connecting this with the fact that none of my other sections show a trace of such multiplied nervures as are seen in those of *Sphenophyllum Stephanense*, figured by M. Renault,† I still conclude that my examples are true *Asterophyllites.* It is true that M. Grand-'Eury recognizes a group of Sphenophylla, "où les feuilles, en nombre variable des tiges aux branches, ont un seule nervure radicale et correspondant sur la tige a autant des petites cotés."‡ But the plants which he places in this group are only the several varieties of the well-known and well-marked species, *Sphenophyllum Schlotheimi* and *augustifolium.* That my plants do not belong to this group is obvious enough, yet those composing it are the only ones which, like mine, have the "nervure radicale unique." Even were it otherwise the number of the leaf bundles in my specimens are very far from being "correspondant sur la tige a autant des petites cotés." I see no reason therefore for abandoning my original conclusion that my plants are true *Asterophyllites,* and that *Asterophyllites* and *Sphenophyllum* are genera so closely allied that their separate existence finds but little justification in nature.

Before leaving the subject of *Asterophyllites,* I may express my surprise that Mr. Carruthers, in a recent article § reiterates his belief in the occurrence of *elaters* in connection with the spores of *Calamostachys Binneana,* notwithstanding my clear demonstration in my fifth memoir, that they do not exist. Mr. Carruthers implies by this reiteration his continued belief in the Calamitian character of these fruits; whereas the very remarkable difference in the structure of the cellulo-vascular axes of the two plants renders it absolutely impossible that such can have been the case. I need only quote the late Dr. Robert Brown's estimate of the value of such differences. "To the argument derived from an agreement in structure between axis of stem and strobilus I attach considerable importance, an equal agreement existing both in recent and fossil Conifera."||

It is curious that both M. Grand-'Eury and Dr. Dawson have fallen into the accidental error of making me regard the *Calamostachys Binneana* as belonging to

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[*] Bulletins de l'Académie Royale de Belgique, 2^{me} série, tome xvii. p. 138.

[†] Annales des Sciences Nat., 5^{me} serie, Bot. tom. 18, plate 4, figs. 3 and 4.

[‡] *Loc. cit.*, p. 49.

[§] 'Contemporary Review,' February, 1877.

[||] "Some Account of Triplosporites, an undescribed Fossil Fruit," Trans. Linn. Soc., vol. xx. p. 471.

Calamites, whereas I have most strongly opposed that idea,* on the identical grounds recognised by Dr. Brown in the case of Triplosporites, viz., that there must be a correspondence between the internal structure of the stem and that of the axis of the strobilus whenever the two belong to the same plant, which correspondence not only does not exist in the plants in question, but is as remote as possible from doing so.

Lepidodendron and Sigillaria.

Notwithstanding all that has been done in elucidating the relations of these two groups of plants much still remains obscure. The present position of the question appears to be this. The first stem of a *Lepidodendron* discovered, in which the internal organization is preserved, was that historic one originally described and figured by Witham,† and named by him *L. Harcourtii.* The same specimen was further described and figured by Lindley and Hutton,‡ and again by Brongniart.§ This plant, which in my opinion only represents one extreme modification of the *Lepidodendroid* organization, and that the least highly organized one, was for so long a time the only known example in which the internal structure was preserved, that it came to be regarded, especially by Brongniart and those who implicitly accepted his conclusions, as typical of the entire Lepidodendroid group. In the volume which contained his description of his *Lepidodendron,* Witham described his *Anabathra pulcherrima* (*loc. cit.,* p. 74, plate 8, fig. 7–12), a plant which, as we now know, only differs from the *Lepidodendron* in having a second exogenous vascular zone, enclosing the primary one of the Lepidodendra. Witham does not hazard any opinion as to its botanical affinities. Brongniart ignored this plant in his 'Vegetaux Fossiles,' but at a later period he obtained a specimen which he made the subject of his classic memoir on *Sigillaria elegans.*|| This latter plant possessed many of the features of Witham's *Anabathra,* but exhibited some differences in the structure of its inner vascular cylinder, which in *Sigillaria elegans* consisted of an *interrupted* vascular ring, whilst the *Anabathra* displayed a *continuous* one. Then followed the publication of Corda's 'Flora der Vorwelt,' in which the author describes his genus *Diploxylon,* a form which unites the features of *Lepidodendron Harcourtii* with those of *Sigillaria elegans,* having the *continuous* inner vascular cylinder of the former associated with the exogenous zone of the latter. In his 'Tableaux des genres de Végétaux Fossiles,' p. 57, Brongniart very properly places Corda's genus *Anabathra* amongst his "Sigillariées," and with equal accuracy identifies it with the *Anabathra* of Witham. Various other publications by Dr. Dawson, Mr. Binney and myself have followed those quoted,

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* See my fifth memoir, Phil. Trans., 1874, p. 65.

† 'The Internal Structure of Fossil Vegetables, &c.,' 1833, p. 51, plate 13.

‡ 'Fossil Flora,' tom. ii. p. 45, plates 98 and 99.

§ 'Vegetaux Fossiles,' p. 38, plates 20 and 21.

|| Arch. Mus., tom. i. p. 405, plates 25–28.

besides those of M. RENAULT and M. GRAND-'EURY to which I shall have to refer more specially. But the point at issue resides in a nutshell. One school follows BRONGNIART in believing that *Lepidodendron Harcourtii* is the true typical representative of the structure of the Cryptogamous Lepidodendra, whilst *Sigillaria elegans* and *Diploxylon* represent the Sigillariæ which are not only supposed to have no affinity with the Lepidodendra, but belong to the very different group of the flowering Gymnosperms.

In several of my previous memoirs I have arrayed a series of facts which appear to me conclusive, and which lead me to reject this separation of the Lepidodendra from the Sigillariæ, and I should have been inclined to have left those facts, and the arguments based upon them, to stand or fall by their own accuracy. But in his recent volume on the coal-measures of Central France, my friend M. GRAND-'EURY has put my arguments in so erroneous a form, that I deem it necessary to correct the errors, and to advance additional evidence in support of my views. In my third memoir, I showed in a way which no one has attempted to answer, that, in its young state, the *Anabathra* of WITHAM is a true Lycopod, of the type of *Lepidodendron Harcourtii.* But that after a time, in addition to *the inner ring of vessels characteristic of the Lepidodendron,* it began to develop *the outer exogenous ring characteristic of* BRONGNIART'S *family of Gymnospermous Sigillariæ.* The conclusion to which these facts lead us is inevitable, and the argument unanswerable, except it can be shown that I am mistaken in my facts, which no one has even attempted to do. I have very little doubt but that this plant which M. BRONGNIART'S theory converts into a Cryptogam in its youth and a Phanerogam in its mature life is really the *Lepidodendron Veltheimianum.* It must be understood that I have sought to demonstrate the organic unity of the Lepidodendra and the Sigillariæ by showing that plants which are unquestionable Lepidodendra gradually acquire the internal features supposed to be characteristic of the Sigillariæ. In the second of my memoirs,* I have shown that the bark of *Favularia* and of a true *Sigillaria,* have a structure which is identical with that of *Lepidodendron,* but this is only a secondary illustration of their unity, auxiliary to that based upon the development of their vascular axis. Such being the case, I was surprised to find in M. GRAND-'EURY'S recently published work the following remark, "M. WILLIAMSON dit avoir trouvé une série de spécimens établissant l'identité des Sigillaires avec les Lépidodendrons. En suivant son opuscule, on voit que l'auteur passe à cette conclusion par des faits isolés, d'après l'analogie de l'écorce et non par des exemples complets réunissant les caractères extérieurs aux caractères intérieurs" (*loc. cit.*, p. 177). I have already said sufficient to show that this paragraph involves a serious error on the part of its author, which is not removed by the remarks that follow it. On the same page as that from which I have quoted, M. GRAND-'EURY makes the important admission, "Il est au moins curieux que, à part le corps vasculaire, les autres parties des Sigillaires soient semblables aux parties correspondantes des Lepidodendrons," and he further adds, "Cette égale composition descend jusque dans

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* Phil. Trans., 1872, pp. 210 and 212.

le Stigmaria." About the truth of these remarks there is no doubt, and seeing that the difference in their "corps vasculaire," is, as I have shown in the case of the Burntisland plant, merely one of age and growth, I marvel that M. GRAND-'EURY does not discern whither his own admissions lead him.

I will now call attention to some further details in the organization of *Lepidodendron selaginoides,* which approaches the nearest to the type of *L. Harcourtii* of any of the Lepidodendra. This is the plant which Mr. BINNEY designates *Sigillaria vascularis.* I presume that he does so *because* it possesses a thin exogenous vascular zone. If so, he merely reasons in a circle, since, with this exception it does not possess a solitary feature connecting it with the Sigillariæ; it does not display the faintest trace of the longitudinal ridges and furrows so characteristic of the true Sigillariæ, whilst, as I have already shown,[*] its bark and leaves display every feature that characterizes a true *Lepidodendron,* a conclusion in which I am supported by the opinion of Mr. CARRUTHERS.[†] I am indebted to Mr. JAMES SPENCER, of Akroydon, near Halifax, for the specimens from which I have obtained the fine additional sections now figured.

It is not necessary to enter again into a detailed description of the structures representing the medullary axis of the plant, in which axis cells and vessels are more or less intermingled in a way that is essentially Lycopodiaceous. I have already done that in my second memoir just quoted, and later observations have suggested nothing that requires either to be added to or retracted from my previous descriptions. Fig. 33 is a portion of a transverse section of a stem in which *c* represents some of the peripheral vessels of the medullary group, which group represent the primary vascular bundle of a young axis. That these vessels increase with age up to a certain point, both in size and number, is unquestioned; but I am still as far as ever from learning where and by what agency the increase in number has been effected. At *d* we have part of the exogenous zone, composed of radiating laminæ (*e*) of vessels that increase in size from within outwards, and which laminæ are separated from each other at very frequent intervals by the medullary rays, *f.* The innermost cortical layer is seen at *g*, *g′*, *g″*, the latter being a narrow band bridging over the space so constantly left vacant, and showing that, when occupied by its original tissues, it consists of parenchyma like that seen at *g.* At *m, m,* are two vascular bundles passing outwards through the bark. Nothing can be more clear than that, whatever may be the mode of increase in the vessels constituting the cylinder *c,* and which represents the vascular cylinder of *Lepidodendron Harcourtii,* in the outer zone, *d,* we have a definite example of exogenous growth, but one in which, unlike the Diploxyloid forms from Burntisland and elsewhere, only undergoes a very limited development. At *m′* we find one of the foliar bundles of small vessels issuing directly from the inner or medullary series of vessels, *c,* and passing outwards through an opening in the

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[*] Phil. Trans., 1872, Plate XXIV., figs. 1, 5, and 6.

[†] 'Monthly Microscopical Journal,' Oct. 1, 1869, p. 179.

exogenous zone, *d*, in order to reach the bark, as the bundles, *m*, *m*, have already done. It will be seen that whilst the latter bundles are intersected almost transversely, *m′* is almost intersected in the plane of its vessels. Longitudinal sections will explain this difference.

Fig. 34 represents a magnificent section of a stem enlarged nearly three diameters, in which the relations of the various parts to each other are well seen. At *a* we have the medullary axis consisting of intermingled cells and vessels; the former being the most abundant in the centre and the latter exclusively forming the peripheral region, as seen in fig. 33 *c*. *d* is the exogenous layer which forms a cylinder the thickness of which is small contrasted with the diameter of the central medullary axis. At *g* we have the delicate parenchyma of the inner bark; at *h* the coarser parenchyma of the middle bark, and at *i* is the thin prosenchymatous layer seen in all these Lepidodendroid and Sigillarian stems, and which is generally preserved when all the other tissues have disappeared. The persistent bases of the numerous leaves are seen at *l*. This section demonstrates the regularity with which the foliar vascular bundles are given off; but more enlarged figures reveal their relations more clearly.

Fig. 35 represents a portion of fig. 34 enlarged 20 diameters. At *c* we perceive the large barred vessels of the medullary axis. At *d* we have the smaller barred vessels of the exogenous zone; at *g*, *g* are several portions of the delicate parenchyma constituting the inner bark, and which is so frequently more or less destroyed. At *m* we have a bundle of small barred vessels issuing from the *exterior* of the medullary axis, *c*, and passing obliquely upwards and outwards through the exogenous zone, *d*, and then ascending almost vertically through the inner bark at *m′*, an arrangement which explains why, in fig. 33, the bundles, *m*, are intersected transversely, whilst *m′* is cut through more nearly in the plane of its long axis. Both figs. 33 and 35 show that the foliar vascular bundle passes outwards accompanied by some cellular parenchyma, either derived from the medullary axis, or more probably from the primitive tissue of the bark through which the bundle passed before the exogenous layer began to be formed. Fig. 36 represents a tangential section of the thin exogenous vascular zone, of which *e* indicates the vessels, *f* the numerous small medullary rays, and *m*, *m*, two lenticular openings through which the foliar vascular bundles have been transmitted in passing from the outermost medullary vessels, where they originate, to the bark and leaves. Fig. 37 represents another portion of fig. 34, but only enlarged 10 diameters, for the purpose of illustrating the course followed by the foliar vascular bundles; at *m* one of these bundles is seen passing obliquely upwards and outwards through the exogenous zone as represented in fig. 35. After passing obliquely through that zone the bundle bends perpendicularly upwards, running for a little distance parallel to, and almost in contact with its external surface. *m′* represents a second foliar bundle ascending from the next node below. At its lower extremity, like the upper part of *m*, it ascends parallel with the exogenous cylinder; but on reaching a point a little above that at which the bundle *m* emerges from the exogenous zone it bends outwards horizontally and almost at a right angle to its former course, to reach the middle bark, where it again ascends obliquely outwards to reach the leaves. This is the course followed by each one of the numerous bundles seen in fig. 34.

On comparing the above facts with what I have already described in my third memoir,* we cannot fail to see that though the exogenous cylinder of *Lepidodendron selaginoides* is much less developed than in the conspicuously Diploxyloid Burntisland plant, the essential conditions in each are absolutely identical. Thus figs. 35 and 36 of the present memoir are virtually copies of figs. 10 and 13 of the older one, just as all the sections of the leaf bases of these two plants equally demonstrate their true Lepidodendroid character. Here, then, we have two Lepidodendroid plants which possess, *in different degrees of development*, the vascular organization which M. BRONGNIART believed, and which his disciples still believe, to be characteristic of Sigillarians plants, and which, on the evidence of that organization, they regard as Gymnospermous Phanerogams. Much too clear headed not to see the force of this kind of evidence, M. GRAND-'EURY endeavours to evade the inevitable conclusion to which it leads by saying, "Tout cela ne prouve qu'une chose; c'est que certaines impreintes de Lepidophloyos peuvent appartenir à des vegetaux Dicotylédones." Remembering the absolute identity in all the other features of the stems of Lepidodendra and Sigillariæ, and which identity M. GRAND-'EURY has acknowledged to exist, is it not more rational to admit that some of these arborescent Lycopodiaceæ have been provided with a pseudo-cambial layer from which they developed an exogenous zone, than to transfer the genus *Lomatophloios* from the Lycopodiaceæ with which all authors agree to arrange it, to the very different Phanerogamous Gymnosperms with which M. GRAND-'EURY would thus unite it. My indisputable facts stand in the way of BRONGNIART'S hypothesis, which M. GRAND-'EURY adopts in its totality, and, as it appears to me, he endeavours to evade them by the adoption of an explanation which has no foundation of fact on which to rest.

The great misfortune has been that *Lepidodendron Harcourtii* was so long the only Lepidodendroid stem of which the organization was known, hence, instead of being rightly interpreted as one extreme modification of the Lepidodendroid type, of which *Sigillaria* presented the opposite extreme, it came to be regarded by M. BRONGNIART as *the sole* typical form.

I need say little here about the views of Dr. DAWSON on the affinities of Sigillariæ. They have now advanced some way in the same direction as mine. He has discovered in Canada a *Sigillaria* with a true Diploxyloid axis, and which is very different from the type of *Sigillaria* that he has described in some of his earlier memoirs. This fact, and the study of a specimen of *Lepidodendron Selaginoides* which I forwarded to him has led him to the following conclusion, which I quote, because where so much discrepancy exists in the minds of some of those most experienced in the study of coal-plants, it is

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* Phil. Trans., 1872.

important to record every step of advance in the direction of unity of view. He says, "the slice enclosed shows very well what I would call the *most perfect* kind of Lepidodendron structure, and which, but for the better development of the woody cylinder in *Sigillaria,* comes very near, if not quite up to, the lowest type of the latter." "Your Lepidodendron is *perfectly exogenous,* and therefore enters into that general type which leads up to the highest plants." "As for me, I do not doubt the truly exogenous character of the stems of *all* Sigillariæ, and *some* Lepidodendra, and that some of the forms approach very closely to each other." * All the phenomena tend to confirm my previous conclusions that Lepidodendra and Sigillariæ belong to the same type of vegetation; that they are equally Cryptogamic plants, but that the Sigillariæ represent, so far as their vegetative organs are concerned, the highest modification to which the Lycopodiaceous type has ever attained.

Lepidodendroid Reproductive Organs.

I some time ago discovered a few singular fringed macrospores, both in the Oldham and the Halifax beds. More recently both Mr. JAMES SPENCER, of Ackroyden, near Halifax, Mr. BINNS, of Delph Hill, in the same district, and Mr. EARNSHAW, of Oldham, have forwarded to me numerous examples of the same objects. We have not yet obtained these macrospores in union with the *Lepidostrobus* to which they have belonged, but it is most probable that one of two that I have received has been their parent strobilus. One of these is a crushed one, abounding in microspores. For this I am indebted to Mr. BINNS; both that indefatigable worker and Mr. SPENCER have sent me sections of another one, which I shall describe in detail. The microspores of the former of these strobili display no peculiarities; figs. 48 and 71, exhibit some of them enlarged 160 diameters. The second *Lepidostrobus,* on the contrary, is a very remarkable one.

Fig 53 represents a slightly oblique transverse section of it from Mr. BINNS' cabinet. Fig. 54 is a slightly oblique tangential one, from Mr. SPENCER'S Cabinet, made nearly in the plane of the outer surface of the common axis of the strobilus. Fig. 55 is also an obliquely tangential section which I have obtained from a fragment forwarded to me by Mr. SPENCER. Fig. 56 is part of a nearly longitudinal section from the same fragment, and fig. 57 is the central sporangium of fig. 55 enlarged 75 diameters. The medullary tissues, as well as the innermost cortical layer, have disappeared from all these sections. In fig. 53, a large Stigmarian rootlet, *x*, has nearly filled the internal cavity thus left, pushing aside the vascular axis, *a*, which has been a cylinder consisting of unusually small barred vessels, each having a diameter of about ·001.† To facilitate reference to the figures the same letters are affixed to identical organs in all

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* In litera. April 11, 1877.

† I have recently received some fine transverse sections of this cylinder, the details of which will be described in a forthcoming memoir. June 10th, 1878.

the fine sections 52 to 57. The vascular axis has been enclosed in a thick cortical layer. The innermost portion of this bark doubtless consisted of a delicate parenchyma, which has disappeared, but there remains a thick middle and outer portion, *b*, the former being composed of a less dense tissue than the latter which consists of oblong, more or less prosenchymatous cells, fig. 56*b*. From this cortical axis there spring numerous sporangiophores, *c*, arranged in the spiral order common to the Lepidodendroid stems. This is well shown in the tangential section, fig. 54, where their bases are seen at *c*, whilst at *c′* their narrower cylindrical portions are divided transversely. The centres of these latter have evidently been occupied by prolongations of the delicate parenchyma of the inner bark, but which, like that tissue, have disappeared. In some of the sporangiophores we find the vascular bundle which also connected them with the main vascular axis. At their outer extremities these sporangiophores expand into peltate disks, 54, 55, and 56 *c″*.* The section, fig. 53, appears to have been made near one extremity of the strobilus where some of these disks, seen at the right hand part of the figure, are in close contact with each other (53, *c*), and in some cases these sporangiophores are actually confluent (53, *c‴*). Fig. 55 demonstrates that each sporangiophore supported one sporangium, *d*, on its upper surface, the two having apparently been attached to each other about midway between the base and the peltate extremity of the sporangiophore; the walls of the sporangia are composed of a single layer of cells (fig. 57, *d*), which are always somewhat oblong and frequently prosenchymatous (fig. 38).

But it is in the interior of the sporangia that the chief interest of this fruit resides. Lepidostrobi containing spores have been frequently described, but this is the first instance I have met with in which the mother cells of the spores with their numerous sister cells, are preserved with such remarkable definiteness.

The sporangia, as already observed, are composed of a single layer of very strong prosenchymatous cells (fig. 38) like those composing the outer cortical tissue of the axis and its branches, though of smaller size. They differ in this respect from those of the Burntisland *Lepidostrobus*, described in my third memoir, in which the sporangium-wall consisted of at least a double row of parenchymatous cells arranged vertically to the surface of the sporangium. Within the sporangia are clustered a number of remarkable objects, some of which are represented in the series of figures from 39 to 47.

One of the common forms of these objects is shown in fig. 39, where we have a central cell, *a*, containing a protoplasmic (?) mass, *c*, and with a curious oblong appendage, *d*, *d*, at each end, which appendages we shall find to be two sections of a remarkable cell. In fig. 40, we have a similar cell, but in these we find, that in addition to the outer cell-wall, *a*, there is a second inner one, *b*, and a third, *c*, which latter has, I presume, been the outer layer of the protoplasm or primordial utricle.

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* In the latter figure two sporangia appear *vertically* between the two sporangiophores, but the lower one, *d′*, is merely a portion of the wall of a sporangium belonging to the next *lateral* series.

We still see the two terminal appendages, *d, d.* Fig. 41 represents a similar cell, *a,* but here the two terminal structures, *d, d,* are less regular, and their boundary walls are spread out into flat surfaces of cell tissue. In figs. 42 and 43 we recognise repetitions of fig. 39, only in the interior of the outer cell, *a,* we find a number of small spherical bodies, *f,* which, in fig. 42 are seen to be enclosed within the second membrane, *b.* Figs. 44, 45, and 46, represent what, at the first glance, look like very different objects, but which intermediate forms demonstrate to be identical with the rest, only seen in different positions. We now see that the cell, *a,* is a four-sided object exactly resembling, in all but size, an ordinary microspore of a *Lepidodendron.* This is best seen in 44 and 45, the projecting apex of the cell having, in fig. 46, been ground away in making the section. That this spore-shaped structure is identical with the cell, *a,* in the other figures, is shown in fig. 47, where we have the general contour of figs. 39 and 42, but combined with the projecting triradiate ridges, *e,* of figs. 44 and 45. We thus learn that the terminal appendages, *d,* of the figures just described, are transverse sections, *d′,* of the large curved cell, *d,* seen in contact with the largest curvature of the spore-shaped body in figs. 44, 45, and 46. In fig. 44 the larger or convex border of the embracing cell is seen to be slightly keeled, which explains the peculiar shape of the sections of these cells as shown in figs. 39 and 42. In fig. 46, in addition to this cell, *d, d′,* we find some narrower ones, *g, g,* so that the triquetrous, conical body, *a,* looks as if it were planted by its broad convex base upon a triangular, multicellular scale. This condition exists in a very large number of the examples discovered; I have not found a solitary instance in which the spore-shaped body, *a,* is entirely detached from its cellular surroundings. However small, some fragment of the encompassing cellular tissue is invariably seen adhering to it, as in fig. 44. In fig. 52, a spore, like fig. 44, is shown in another aspect, so that the crescentic cell, 44, *d,* is seen crossing the disk of the spore, like a flat band, 52, *d′,* and connecting the two terminal appendages *d, d.* The peculiar mode in which these supposed spores are combined with the cells and portions of cells to which they are attached, receives its explanation when we examine the section, fig. 57, which represents one of the sporangia of fig. 55 enlarged 50 diameters. Enclosed within this sporangium we discover nine clusters of tetraspores, each cluster being held together by its group of mother and sister cells. The peculiar triangular group of fig. 46 reappears in the clusters, *g, g′,* of fig. 57, only each cluster has now its full complement of four spores. The triangular contour of each group obviously indicates a cluster of cells derived from a common parent cell, which has packed itself between other similarly derived clusters and the sporangium wall, modifying its shape according to the resistance its expanding elements had to encounter. Several of these clusters exhibit the curious crescentic cell, *g′, g′,* seen in fig. 46, *d,* as well as in figs. 44 and 45. In like manner, many of the tetraspores exhibit in their interior the protoplasmic (?) masses seen in figs. 39, 40, and 41, *c.* A peculiar feature of these sporangia, and one in which they differ from those of all Lepidostrobi with which I am familiar, is their shape. They present nearly the same form and dimensions, in whatever direction they are intersected. In this respect they remind us of the supposed fruits of *Asterophyllites,* as represented by my *Volkmannia Dawsoni,** rather than of true Lepidodendroid structures. But the spiral arrangements of the strobilus under consideration, and the verticillate ones of the *Volkmannia,* place them widely apart.

Several important questions arise out of the study of this fruit, but which mainly centre in one, viz., what are these tetraspores?

On first examining these specimens, I was inclined to believe that the triquetrous body, *a*, was a large microspore, and that the enclosed spherical objects seen in figs. 42, 43, and 44, *f*, were identical with those figured by HOFMEISTER in plate lvii., figs. 13, 14, and 15, of the Ray Society's edition of his 'Higher Cryptogamia.' But two reasons militated against this conclusion, 1st, the large size of the spore-like bodies, *a*, and 2nd, their invariable adhesion to greater or smaller portions of cellular tissue, whereas developed microspores are invariably free. To illustrate the question of size I have, in figs. 48, 49, 50, and 51, drawn some true microspores to the same scale, *i.e.*, enlarged 100 times. Fig. 48 represents three *detached* microspores from the crushed *Lepidostrobus* supplied to me by Mr. BINNS, and fig. 77 three others, all from the same bed near Halifax as the specimens under consideration. Figs. 49 and 50 represent two clusters, each consisting of four microspores (only three being visible), from two Oldham examples of *Lepidostrobus.* Fig. 51 represents a similar cluster from a sporangium of the recent *Lycopodium alpinum.* It will at once be seen that the size of each of these small microspores differs so widely from that of the large bodies under consideration as to make it most improbable that the latter can also be microspores. Three other possibilities remain—1st, they are macrospores; 2nd, they are the mother-cells of microspores, the granules, *f*, seen in figs. 42, 43, and 44, being the true microspores in an early state of development; 3rd, they are *spores* of a special kind, belonging to a strobilus of the type of the recent *Lycopodium,* and which only possessed one kind of spore. The latter appears to me to be the more probable explanation of their nature, though the second supposition is not an impossible one, nor without its illustration amongst living Lycopods. Thus in plate lvii., fig. 10, HOFMEISTER figures the mother-cells of the microspores of *Selaginella Martensii,* which are arranged in such a manner as to give each cell one rounded side and three flat ones, terminating at a projecting angle. This is exactly the form of my examples. Whenever I obtain the specimens attached to their surrounding cells, I invariably find that each of the spore-shaped bodies, *a*, rests upon those cells by its larger concave surface, whilst its other three sides stand up in bold relief, the conical apex being uppermost and wholly free, as in figs. 44, 45, and 46. Fig. 57 demonstrates that four of these bodies were primarily in juxtaposition, as the common products of one large fertile parent cell, and that the surrounding cells, *d* and *g*, seen in fig. 46, were barren cells belonging to the same cluster as each of those fertile parent cells.

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* Part V., Plate 5, fig. 28.

Viewing them in this light it is easy to understand the cohesion of all these clusters As grandmother cells of spores, they had not reached the stage of development at which they would be free from their attachment to the other cells of the cluster in one of which they had been specially developed. If this is a correct explanation of these objects, the small spheres, *f*, seen in figs. 43, 44, and 45, become groups of free cells, each one of which would in turn have developed within its cavity, by subdivision of its protoplasm, a cluster of 4 microspores, like those seen in figs. 49, 50, and 51. On comparing the size of these latter objects with the small spheres, *f*, of figs. 43, 44, and 45, it will be seen that a very moderate measure of further development would bring them up to the dimensions of the group of four perfect microspores. I presume that when they reached this stage of growth all the barren cells, *d* and *g*, would have disappeared. I have already observed that in all the specimens of *Lepidostrobus* which I have examined in which the spores have attained to maturity, each male sporangium is crowded with microspores, but it shows no traces of the mother cells whence those spores were derived. In like manner the mother cells of macrospores are as invariably wanting. Hence the existence of numerous barren cells in this *Lepidostrobus* in such a perfect state of preservation indicates that we probably have before us a strobilus in an early stage of its development, whatever may be the true nature of its tetrasporal contents. If these tetraspores are merely the grandmother cells of microspores, the small cells seen in figs. 42, 43, and 44, being their true mother cells, then we have the materials capable of supplying the enormous number of spores seen alike in the microspores of the bisexual Selaginellæ and the ordinary spores of the Lycopodia. If, on the other hand, they are true, and fully grown, spores, belonging to plants of the unisexual type, their magnitude distinguishes them conspicuously from all known similar spores, whether living or fossil.

I have already stated that numerous macrospores of a very remarkable character have been found near Halifax by Mr. Binns, Mr. Spencer, and Mr. Earnshaw, associated with the spores already described. I am far from certain that all these belong to the same plant, but I think there is reason to believe that figs. 58 to 66 do so; of these figs. 58, 59, and 60, 65 and 66 are enlarged 43 times; 61 and 62, 100 times; and 63 is enlarged 214 times; fig. 64 is enlarged 50 diameters.* Fig. 60 is the specimen which I first discovered; subsequently Mr. Binns forwarded to me the examples drawn in the other figures just referred to. Shortly after these drawings were made Mr. Spencer sent me a series of five sections, as well as many more at a later date, which were of material service to me in studying these objects.

Many of the examples consist of a double spore-wall. The outer layer is thick and variously furnished with peripheral radiating appendages. It exhibits no sign of

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* It would have been more convenient had all these figures been drawn to the same scale, but this plan would either have left the smaller ones too indefinite, or would have caused the larger ones to occupy too much space.

structure beyond a granular texture which may merely be the result of mineralization. The inner wall, *a*, figs. 65, 66, 66B, and 66C, though sharply defined, is very thin. So long as I only saw isolated specimens, those represented in figs. 65 and 66, seriously perplexed me, being apparently sporangia full of minute spores. The discovery by Mr. BINNS of the specimen fig. 64, left no further room for doubting that these curious objects are macrospores, of which three are inclosed within a cellular sporangium-wall of the usual type. This sporangium-wall is not, like those described in the previous pages (fig. 57D), composed of prosenchyma, but of parenchymatous cells, whose slightly elongated axes are vertical to the surface of the spore. The latter is also the case with the crushed *Lepidostrobus*, microspores from which are represented in figs. 48 and 77. This difference shows that whilst we have two types of strobilus in the Halifax beds, there is no difference, so far as the sporangium-walls are concerned, between those containing the macrospores and those with true microspores. Hence there exists the possibility, at least, that the latter two may belong to the same plant.

The fringes of radiating appendages which clothe the exteriors of these spores vary much both in their shape and arrangement. They are often simple, as is seen in fig. 58. In fig. 63 most of them are so, whilst in fig. 71 there are no branched ones, yet the former of these two figures is so intermediate between the latter and the common form represented by figs. 58 and 60, as to leave little room for doubting that these several examples merely represent different states of the same spore. I noticed in several of the specimens the peculiar outline represented by *d*, *e*, in figs. 65 and 66, and which looked as if the section had intersected a small projecting peduncle surrounded by a thickened ring. This peculiar form is seen in the two left-hand spores of fig. 64, whilst fig. 64* represents the same appendages as they appear in another spore in Mr. SPENCER'S cabinet, enlarged 40 diameters. In fig. 64 these appendages of the several spores appear to converge towards a common centre. That these can have been peduncles is, of course, out of the question. It appears to me more probable that they may have been appendages similar to the dome-shaped projections developed at the apex of the macrospore of *Pilularia globulifera*, each of which encloses a funnel-shaped entrance into the spore; in these recent objects we also find a thickened ring surrounding the base of this appendage, very similar to that seen at *e*, *e*, in figs. 64, 65, and 66. In 64* we see clear indications that a canal, *f*, passed along this appendage in the case of the fossil spores.

Figs. 65 and 66 are further interesting because of the spherical bodies contained within their interior. These are manifestly small cells developed within the spore. In many of those of fig. 66 we see the protoplasmic and other cell contents preserved in the interior of each cell. I think we can scarcely regard these objects otherwise than as the endospermic cells of the macrospore, destined to be developed into a prothallus. If this is a correct explanation of them their presence in a fossil coal-plant becomes an interesting fact.*

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* Since writing the above Mr. ISAAC EARNSHAW, of Oldham, has kindly prepared for my inspection a

I have already referred to the second or thin inner layer of the macrosporal-wall. This is seen at *a*, in figs. 65, 66, and 66C, but in spores more recently sent to me, both by Mr. SPENCER and Mr. BINNS, I find it yet more conspicuously exhibited in large spores like fig. 58. Fig. 70 represents two hairs from another spore in which there appears to be a thin outer layer detached from the exterior surface of the spore, but I cannot determine whether this was a feature of the living spore or whether it is merely a result of mineralization. Some other specimens render this latter suggestion possible.

Associated with these macrospores both Mr. BINNS and Mr. SPENCER have found some other very remarkable objects, some of which may be young states of the macrospores just described, or they may belong to distinct species of plants. Fig. 72 represents the exterior of what I presume has been a small macrospore, in which the free extremity of each peripheral appendage is trifid; somewhat similar conditions are seen in the yet smaller examples represented in figs. 73 and 74. It is impossible to overlook the striking resemblance of these little objects to the fossil Xanthidia of the chalk flints, and to the zygospores of some of the Desmideæ. In figs. 75 and 76 we have two objects which appear to be of a different nature. Fig. 76 is obviously a cavity about ·007 in diameter. The figure represents an optical section, whilst the faint areolation represents the ends of the cells bounding the cavity but seen a little out of focus. Figs. 75, 75A, 75B, and 75C, are apparently examples of the same organism, only in them less of the surrounding parenchyma is preserved. The diameter of fig. 75 is about ·0012; of 75A and 75C about ·0111, whilst fig. 75B is about ·0166. Fig. 75A, 75B, 75C, and 76 are empty; but fig. 75 is filled with small parenchymatous cells which have a mean diameter of about ·0012. Fig. 75C also contains a mass of parenchyma; some of the cells in the latter specimen are further enlarged in fig. 75D, and two of them are there seen to contain three or four small rounded spheres, *a*, which may possibly be reproductive spores of some kind. These objects appear to be conceptacles of some kind that have been formed in the midst of parenchymatous tissue, but from which they have shown a remarkable tendency to become detached with a somewhat definite yet irregular contour.*

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large number of sections of the Halifax material, and amongst them I have found the two very fine macrospores represented in figs. 66A, and 66B, and in one of Mr. SPENCER'S slides I find the spore, fig. 66C. In 66A, which is enlarged 50 times, the endospermic cells are of uniform size, being about ·003 in diameter. In fig. 66B, these cells are unequal in size, the largest being about the same magnitude as in fig. 66A, whilst the smaller ones are ·0005, a few odd ones being even still more minute. In fig. 66C, we find the cavity of the macrospore filled with irregular parenchyma, apparently resulting from the successive subdivision of a multitude of free endospermic cells, which are thus forming themselves into a prothallus. In the centre of the specimen a small fragment of a barred vessel, which clearly formed no part of the endosperm, suggests the possibility that these cells may belong to some algoid plant that has found its way into an empty cavity, the fragment of a vessel having been accidentally introduced along with the parasites; but two other specimens correspond so closely with that figured that I see little reason for doubting that this parenchyma belongs to the macrospore.

* Fig. 76B not only exhibits this defined contour, but further shows a tendency in the peripheral cells to arrange themselves in fan-shaped or radiating columns at the three points *a*, *a*, *a*. Other specimens

Fig. 76A represents a somewhat similar conceptacle, but in this instance the outer wall of the organism consists of a single layer of cells, *a*, the flattened inner ends of which form the boundary of the conceptacular cavity. The dark ring in the figure merely represents part of this surface of the inner cavity which has not been crossed by the section at its greatest diameter, and which is consequently seen a little out of focus. This example differs from the figs. 75, in the fact that in the former the *outer* extremities of the cells bear no appearance of having been forcibly detached from some other surrounding parenchyma, and only consists of a single row of elongated cells disposed vertically upon the cavity which they invest. This specimen, which is from one of Mr. BINN'S Halifax sections, has a maximum diameter of ·0166. In its interior is what appears to be a collapsed, structureless membrane, *c*, that originally lined the cavity.

I have not yet obtained the slightest clue to the plants to which these curious objects belong; but some of them inevitably remind the botanist of the spore cavities seen in sections of the fertile frond of *Ophioglossum vulgare.*

Fig. 77 represents two detached microspores and one united cluster of four, but of which only three can be seen in any one position. These, which are from a fragment of a Halifax strobilus, are introduced to serve as standards of comparison in reference to the other structures just described. They are enlarged, like the figs. 63–73, 74, and 76, 214 diameters.

Both Mr. BINNS, Mr. SPENCER, and Mr. EARNSHAW have supplied me with examples of the very remarkable objects represented in figs. 67, 68 and 69. Fig. 67 represents a section enlarged 50 diameters, its actual breadth being ·025. Its outer wall, exclusive of its projecting hairs, is about ·0023 in thickness. Fig. 68 represents a segment of the circle enlarged 214 times. The wall appears to consist of a row of cells, fig. 68, *a, a*, shaped like dumb-bells, arranged perpendicularly to the surface of the organism. At the outer and inner surfaces of the structure the enlarged extremities of these cells are in unbroken contact, looking like two layers of ordinary tabular parenchyma; but the middle constricted portions of the cells appear to stand isolated, and to be surrounded by a continuous cavity, fig. 68, *b*, like a chamber whose roof and floor are connected by a series of pillars with bases and capitols. Supposing it possible that the lozenge-shaped spaces, fig. 68, *b*, might be occupied by a central series of cells, I examined the specimens carefully in search of a double cell-wall; but having failed to find anything of the kind, I consider that these are what I have already suggested, viz., a continuous network of inter-cellular spaces traversed vertically by the constricted parts of the cells, and shut in by the continuous outer and inner surfaces of the organism. The specimen just described is from Mr. SPENCER'S cabinet. Fig. 69 represents part of a second specimen sent to me by Mr. BINNS. It is obviously

obtained more recently exhibit the same arrangement. I propose grouping these and some allied objects in a provisional genus *Sporocarpon*, and the present species may be designated *Sporocarpon cellulosum*. June 10th, 1878.

the outer surface of part of a crushed specimen in which the perfect contact of all the outer expanded extremities of the cells composing the wall of the organism is clearly shown.

The hairs, *c*, which project from the outer surface of these specimens are merely the external dilated extremities of some of these cells prolonged outwardly. They are very turgid at what, viewed externally, appears to constitute the base of each hair, but at their peripheral portions they are drawn out into long cylindrical, uncellular structures, *c′ c″*, which appear in some instances to be bifid or trifid at their extremities. Each hair therefore appears to consist of a single cell, the lower end of which is at first turgid, then dumbbell-shaped, the latter portion being prolonged through the wall of the organism, so as to reach its inner surface.

These objects have obviously been spherical bodies. In fig. 67, *d*, we find an organic spherical tissue occupying the interior of the organism. The latter has a shrivelled membraneous look about it, but otherwise displays no traces of structure.

Fig. 69A, is another specimen of the same conceptacle from one of Mr. EARNSHAW'S slides. In it, the central membrane seen in fig. 67, *d*, is filled with small spherical cells, the protoplasmic contents of some of which, as at *a*, have become contracted and detached from the cell-wall. In other respects this example exhibits the same structure as is seen in figs. 67 and 69. These objects may be distinguished provisionally as *Sporocarpon elegans.*

I am acquainted with no recent objects that exactly correspond with these conceptacles. There is some little resemblance between them and the outermost layer of the sporangiocarp of *Pilularia globulifera.* In this latter structure we have a layer of large cells, many of which are prolonged externally into conspicuous hairs, each one of which has a turgid base like those of my fossil; but the subjacent hour-glass form of each cell is entirely wanting in the recent type.

Mr. BINNS, Mr. SPENCER, and Mr. EARNSHAW, have furnished me with slides from the Halifax beds, containing examples of the remarkable type of conceptacle represented in figs. 76A,* 78, and 78A. Fig. 76, *a*, for the original of which I am indebted to Mr. BINNS, represents a sphere composed of a single layer of oblong cells, *a*, the inner ends of which are flattened and in close contact so as to bound a very regular and smooth internal, spherical cavity. These cells continue in close contact throughout the greater part of their length, but their peripheral extremities are free, and more or less rounded. The dark circle, *b*, in the figure, represents a portion of this smooth inner bounding wall of the cavity which happens not to have been cut through, at either surface of the section, in the plane of its greatest diameter. At *c* we have a collapsed inner and apparently structureless membrane apparently corresponding to *d* in fig. 67. At the first glance this conceptacle appears similar to that represented by figs. 75, 76. But this difference exists between the two: in the former the bounding wall of the conceptacular cavity consists of a single layer

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* I have already referred to this figure in p. 182.

of cells, with perfectly free outer extremities. In the two latter, that boundary wall consists of at least a multi-cellular layer, whilst such examples as 75A, and 76, indicate that the entire structure has been embedded in and formed part of a parenchymatous structure. Such has certainly not been the case with the organism now under consideration. I have as yet discovered in the specimens of the latter, no trace of a peduncle, or point of attachment to any other structure. Fig. 76A, is enlarged 324 diameters. I propose to distinguish this object as *Sporocarpon compactum.*

Fig. 78 represents a second form of the same type of conceptacle which I found in a slide sent to me by Mr. EARNSHAW. It differs from the specimen last described only in the greater number and narrower transverse diameter of its peripheral cells, *a*, a feature which results in producing a more definitely regular peripheral outline. The cells are also longer than in fig. 76A, causing the thickness of the bounding wall to be greater in proportion to the diameter of the enclosed cavity. The maximum diameter of the entire organism is about ·009, being enlarged in the plate 214 times. The specimen, fig. 76A, has about the same dimensions. Fig. 78A, represents a single cell of fig. 78; its peripheral extremity, *a*, is broader than its narrower opposite or inner one; its exposed face exhibits two flattened or slightly concave surfaces, resultants of the pressure of two contiguous cells. Each cell of this specimen has a length of about ·0023 to ·0029 and a maximum breadth of ·0005 to ·0006. I have formed no opinion as to the relations of these objects. Fig. 78 may be designated *Sporocarpon tubulatum.*

Before leaving these curious reproductive structures, I would further call attention to a single transverse section of a remarkable little fruit, fig. 103, which I only discovered accidentally in a larger section of one of the Oldham nodules made for the sake of a very different object. Though I carefully examined contiguous portions of the nodule, I could find no further traces of the specimen, a fact indicating that it was either a very short fruit, or only a fragment of a more elongated one. Its mean diameter is about ·05. It consists of a central angular axis surrounded by a circle of what appears to be three, or possibly four curious structures *b*, *b′*, which are evidently symmetrical in their contour and arrangement; the two marked *b*, *b*, appear to retain their original form; it is not so clear whether those marked *b′* retain their normal form, or whether they were originally united, forming a figure with three centripetal and three centrifugal prolongations, like the uppermost one, *b′*. These three or four structures are enclosed within a more peripheral zone, *c*, whilst yet more externally we have numerous bracts, *d*, each one of which bears on its inner surface a rounded or ovoid sporangium, *e*. In the figure these sporangia do not appear so distinct from the bract to which they are attached as they do in the specimen, since in the latter, whilst the bracts are opaque, black, and carbonised, the sporangia are translucent and of a rich, dark amber colour, like the hue of the spores found in coal.* The most definite of these sporangium-bearing bracts are those seen at *d′*, *d′*. The bract appears to have had a V-shaped section, the sporangium being lodged in the inner, concave upper surface of the bract. Each

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* These are now tinted in the figure.

sporangium has a diameter of about ·005. That this has been a strobilus of some kind is unquestionable, and it is equally obvious that it is very distinct from any fruit the internal oganization of which has hitherto been described. It is from the Oldham deposits. It has a Lypocodiaceous look about it, but until we learn more respecting it I would apply to it the provisional name of *Volkmannia* (?) *parvula*.

Ferns.

Two new structures, apparently belonging to this family, have been met with since I wrote my sixth memoir. One of these is a transverse section (fig. 79) of a petiole found in one of the Oldham nodules, by Mr. ISAAC EARNSHAW, to whom I have been indebted for the loan of several instructive specimens from that locality. It obviously belongs to the same type as the *Chorionopteris gleiche* of CORDA.* In CORDA's specimen, the walls of the vessels of the vascular bundles are very regularly reticulated. Though Mr. EARNSHAW's plant is very opaque, I detect distinct evidences that its vessels were of the same reticulate character. Within the doubly incurved vascular bundle is a mass of very small cells, whilst the cortical layer is composed of larger ones. Since I can detect no difference between this Oldham specimen and CORDA's, I venture to attach his specific name to it and designate it, in accordance with my previously adopted plan, *Rachiopteris gleiche*. Its mean diameter is about ·11.

Amongst the new objects with which the Halifax beds have rewarded the researches of Messrs. BINNS and SPENCER, are some stems or roots which for the present I have located in the provisional genus *Rachiopteris*, though I am far from certain that the objects are true ferns. Fig. 80 represents the transverse section of an axis which appears to be of the maximum size of these objects so far as the specimens hitherto discovered enable us to judge. Its diameter is about ·066. In its centre is a cylindrical bundle, about ·025 in diameter, composed of barred vessels. The central ones are very small; the peripheral ones, on the other hand, very much larger, having a mean diameter of ·004. This vascular bundle is surrounded by a thick ring of very minute cells, *a*; the outer margin of this zone, which appears to form a sort of bundle sheath, is rather sharply defined. It is enclosed in a cortical layer of larger cells, *b*, from ·008 to ·016 in thickness, the cells of which exhibit a little tendency to arrange themselves in irregular concentric circles, after the fashion of those composing the root-stems of *Psilotum triquetrum*. Figs. 81, 82 and 83 are three successively smaller axes. In each of these the central vascular bundle consists of but few vessels of various sizes and not disposed in any uniform manner; the central vessel of fig. 81 and the three central ones of fig. 82 being not only the largest in the bundle but actually larger than those occupying its centre in fig. 80. Fig. 83 is further enlarged to 140 diameters in fig. 85. The latter figure exhibits the vascular bundle composed of very small vessels. The line of demarcation between the exterior of the

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* Flora der Vorwelt, taf. liv., fig. 8.

cellular bundle-sheath and the outer cortical layer is indicated by a rather irregular ring of cells, *a*, which have had some peculiar cell-walls, giving them a darker hue than the rest of the section. Fig. 84 represents a segment of fig. 82, also enlarged to 140 diameters. In it the tendency of the inner cells of the cortical layer *b*, to arrange themselves in concentric circles is very marked; also the disposition of the innermost ones to become compressed and narrowed in the radial direction. The bundle-sheath in this specimen has disappeared. Fig. 86 is a portion of a longitudinal section enlarged 60 diameters; the vascular bundle is seen to consist of barred vessels. The bundle-sheath, *a*, is composed of very narrow, vertically elongated, square-ended cells, whilst in the cortex, *b*, the cells are of larger size, of coarser texture, and exhibit a strong tendency to become prosenchymatous. Fig. 87 is a transverse section of a stem like fig. 80, but giving off a long, straight, lateral branch. In this section the large and small vessels of the central bundle are more irregularly intermingled than is the case in fig. 80. On the whole the largest vessels are found at the periphery of the bundle. Judging from the size of its vessels and from its average diameter I presume that a transverse section of this branch would be intermediate between figs. 82 and 83. The section fig. 87, exhibits an extension of the bundle-sheath, *a*, of the central stem prolonged outwards to form the bundle-sheath, *a′*, of the branch, and the cortical layer, *b*, is similarly extended, *b′*. The connexion of the vessels of the branch with those of the central axis is not seen, owing to the slight angle at which the former have been given off from the latter, and which has prevented their direction from corresponding exactly with the plane of the section. Fig. 88 is a transverse section of another stem which exhibits the general features of those just described, but which differs from them in the small size of its central vascular bundle and bundle-sheath, contrasted with the diameter of its cortical outer layer. It is giving off a lateral branch, *a*, which is obviously ascending almost parallel to the main axis. The difference between the size of the vascular axis of the branch and that of the main stem is much less than in fig. 87. Still since this section occurs in the same slide as those represented in figs. 80–87, and since the same slide contains other sections which seem somewhat intermediate between the two extreme modifications, I am disposed to regard them all as belonging to the same plant. The differences between them are not greater than exist in similar sections of the aerial and subterranean stems of *Psilotum triquetrum*, to which the entire series of sections of this plant displays a considerable resemblance.

Three possibilities suggest themselves as to the affinities of this plant. It may be a fern stem, though I know no recent type of fern which it resembles; it may be the root of some type of fern, an idea suggested by the tendency to a concentric arrangement of the cortical cells; or it may belong to some dwarf type of Lycopodiaceous plants. For the present these points must remain undetermined. Meanwhile I would distinguish the plant by the temporary name of *Rachiopteris cylindrica.* I have not seen this form in the Oldham nodules. All the specimens figured are in a slide from the cabinet of Mr. BINNS.

Cordaites.

Two fragments alone, both from the Halifax deposits, whence they were sent to me by Mr. BINNS, seem to resemble objects figured by M. GRAND-'EURY * which belong to Cordaites. One of these closely resembles the section of a leaf represented in Plate 18, fig. 1 of the work cited. The other is a fragment of epidermis (fig. 89) with numerous large and closely grouped stomata. The epidermal cells have disappeared, but the stomata are clear and distinct. From the large size of the area enclosed between each pair of guard-cells I presume that there has been a second inner pair to each stoma, but I cannot trace any division line in that area separating such cells. It is possible that this specimen may have belonged to some other plant than Cordaites, but it corresponds most closely with M. GRAND-'EURY'S fig. 1″, in his Plate 18. Fig. 89 is enlarged 360 diameters; the vertical length of each stoma is about ·0009, and its diameter about ·0006.

I am indebted to Professor YOUNG and Mr. J. YOUNG, of the Glasgow University, for a fragment of very curious wood from the Volcanic Ash of Arran; fig. 90 represents a portion of a transverse section of this specimen enlarged 16 diameters. Fig. 91 is part of the same section further enlarged to 50 diameters, and fig. 92 is a tangential section, enlarged like fig. 90, 16 diameters. The structure of this specimen will be best understood by first examining the tangential section. It exhibits a series of vascular laminæ, *a*, composed of rather large reticulated vessels, and which form a very irregular network, *a*, *a*, enclosing a multitude of areas, *b*, *b*, which are equally irregular in size and form and which are filled with intersected cells. On turning to the transverse section, fig. 90, we find that these vessels are arranged in rather regularly disposed laminæ which have radiated outwards from the central axis of the stem. This is seen clearly wherever these laminæ have been intersected at right angles to the direction followed by the vessels, as at *a*, *a*; but in other places, as at *a′*, *a′*, the vessels are cut through nearly in the plane of their course as they bend round to rejoin other neighbouring laminæ, and thus enclose the cellular areas, *b*, *b*.† The same section shows that the cellular tracts, *b*, are composed of a modified form of prosenchymatous cells, grouped in masses which have radiated from the centre of the stem to the bark, the long axis of each of the component cells following the radial direction of these masses as a whole. These cell masses are, in fact, huge medullary rays of a most extraordinary form. Fig. 91, *b*, illustrates the character of these oblong cells, as well as the minutely reticulated structure of the walls of the vessels, *a*. Some of the cells have square ends; more frequently they have oblique overlapping ones. They have the appearance of possessing thickened walls, which are translucent, whilst their cavities are occupied by carbonaceous matter, but whether this effect is due to original lignification of the cell-walls, or

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* Flore Carbonifère du Departement de la Loire, &c.

† The upper and lower margins of this figure severally represent the medullary and cortical borders of the section.

to some mineralization of them, I am unable to determine. It is needless to point out how much fig. 91 resembles the ordinary aspect of a radial section of a wood with the mural cells of its medullary rays crossing the vessels at right angles to the vertical course of the latter.

The only stems which I have examined that bear any resemblance to the one now described are those of *Lyginodendron Oldhamium*, illustrated in my fourth memoir, and in which the medullary rays are of unusual size; but in that plant the vertical length of each ray, as seen in tangential sections, many times exceeds its breadth. This is not the case with the plant under consideration. Though opposed as a rule to giving names to detached fragments of wood, this one appears to have such remarkably distinctive features, that I venture to designate it *Lyginodendron anomalum*. It may be remembered that the late Mr. GOURLIE described casts of the bark of a *Lyginodendron* from the Scotch carboniferous deposits. It will be an interesting fact if the specimens now described prove to belong to the woody zone of Mr. GOURLIE'S plant. Should they do so, the genus *Lyginodendron* will be characterized by the possession of a most distinctive internal organization.

The Oldham calcareous nodules very frequently contain fragments of wood of various kinds, which, on examination, often prove to be masses of cortical cellular tissue. A very large fragment of this kind was found by Mr. NIELD, to whom I am indebted for the specimen from which the sections that I am about to describe were made. The entire fragment is about 3½ inches in diameter from its medullary to its peripheral surfaces. At its inner portion it consists of parenchyma, the cells of which are not arranged in any regular order. Their transverse diameter (fig. 96) is about ·01, whilst they are a little elongated vertically, many of them having a diameter, in that direction, of ·02 (fig. 97). In these vertical sections many of the cells exhibit clear evidences of their meristem origin in the secondary, but perfected, divisions seen within many of the older cells (fig. 97, *a*, *a*). Proceeding from within outwards, we soon find, in transverse sections, that these cells tend to arrange themselves in radial lines (fig. 93A) whilst radial vertical sections (fig. 94) show that as they do this, the cells increase in vertical length, and their longer sides approach more and more to perfect parallelism with each other. But in addition to this parallelism, the cells display a disposition to group themselves in well-defined clusters, each cluster being longer in the radial than in the vertical direction. This arrangement, as is seen in fig. 94, *a*, continues to prevail until we reach the peripheral margin, *b*, of the specimen. No signs of this peculiar grouping appear in transverse sections *of this part of the specimen* where, at about an inch from the inner or medullary surface of this bark, we obtain the condition represented in fig. 98, which is part of a transverse section, and in fig. 99, which is a tangential one of the same part. The whole tissue has now assumed a prosenchymatous character, the cells being arranged in very regular and uniform radiating lines proceeding from within outwards. These cells now have a transverse diameter of about ·0041 to ·0027, whilst many of them are ·025 in length; fig. 93, *a*, exhibits their collective aspect in transverse sections, and fig. 94, *a*, in vertical radial ones, whilst fig. 100 represents a portion of the radial section enlarged 15 diameters. The latter figure illustrates the way in which these cells are arranged, in long radial lines, most of the component cells of each of which are of exactly equal length, such groups constituting the peculiar limited clusters already referred to. The cells now present conspicuous examples of what has been termed "prismatic parenchyma." As we approach the peripheral surface of the bark, we find the new and very characteristic conditions illustrated by the figures 93, 94, 95, and 101. The outermost layer is seen to be an irregular parenchyma (fig. 93, *b*, 94, *b*), but even in this portion we again discover a tendency on the part of the cells to throw themselves into groups, the component cells of which have evidently some common bond of union separating them from similar neighbouring groups ; but intermediate between this outer portion, *b*, and the prismatic cells, *a*, we find a curious arrangement. In fig. 93, some of the long contiguous parallel lines of prismatic cells gradually diverge in opposite directions, and allow of the intercalation of long, wedge-shaped rows of cells, *c*, *c*, whose longer division walls are again parallel to each other, and to the periphery of the bark as well as transverse to the radial direction of each individual wedge. On tracing these wedges inwards, *i.e.*, towards the medullary surface of the bark, *we find them to be continuous with one or two of the lines of prismatic cells*, fig. 93, *a*. Hence it is clear that the one tissue stands in some definite relationship to the other. At their peripheral extremities these lines of parallel cells merge in those of the superficial parenchyma, *b*. On turning to the vertical radial section, fig. 94, we find that though in the transverse section, each of these wedges usually consists of but a single linear series of cells, in the radial vertical one it consists of several such series (fig. 94, *c*) superimposed vertically upon each other, and interposed between the separated layers of prismatic cells, fig. 94, *a'*, *a'*. This section further reveals to us the fact that these cells are grouped in lenticular clusters, which form a part of the continuous series of such clusters seen in the prismatic tissue of the bark at fig. 94, *a*. The vertical partitions of the cells of each group, 94, *c*, are parallel to each other at the more internal parts of the bark, the cells having about the same dimensions as they possess in the transverse section, fig. 93, *c*, but as we approach the peripheral parenchyma, *b*, the cells of each cluster become shorter, broader, and less regular, assuming more and more the form of ordinary parenchyma.

Fig. 95, which is a tangential section of the tissues under consideration, made along a line between the two stars of fig. 93, reveals a remarkable arrangement. We now find the prosenchymatous or prismatic cells forming a regular network, *a'*, *a'*, enclosing numerous lenticular areas filled with parenchyma, fig. 95, *c*, *c*, and as the section has penetrated more deeply into the bark at *a''*, than it has on the left hand portion of the figure, we see that these parenchymatous areas become gradually smaller (fig. 95, *c'*, *c'*), and finally almost disappear, the cells merging in the mass of prismatic tissue, *a''*. It thus appears that the cells seen in fig. 93, 94, and 95, *c*, are really tabular cells whose broad parallel sides are parallel to the surface of the bark, whilst their shorter axes are radial. In a word, these cells stand upon their thin bevelled edges, with their two flat parallel surfaces severally directed towards the medulla and the periphery of the bark. It is also clear that they are grouped into lenticular, vertically extended, wedge-shaped masses, whose thin edges project inwards between the rows of prismatic cells.

But fig. 101, which is a portion of fig. 95, enlarged 16 diameters, reveals some further peculiarities. The prismatic cells, *a*, *a*, now exhibit their somewhat prosenchymatous aspect, whilst, in the parenchyma, the darker outlines, *c*, obviously indicate the boundaries of the tabular cells seen in figs. 93 and 94, *c*; but we now discover that these cells are in the condition of extremely active meristem, most of them containing secondary subdivisions, their thin secondary cell walls, *c*′, intersecting the cavities of the primary cells, *c*, in every direction. It is thus clear that the network of prismatic or prosenchymatous cells, *a*, *a*′, *a*″, represents permanent, or formed tissue, whilst the cellular masses, *c*, which that network encloses, have been in an active state of cell multiplication; the same activity also appearing, though less conspicuously, in the peripheral parenchyma, *b*, of the bark.

I can arrive at no other conclusion than that we have here a sub-epidermal plane of parenchymatous tissue in a state of genetic activity, and that it is from this growing tissue that the additions have been made to *the exterior* of the prismatic tissue, *a*, which is thus developed into a thick modification of corky structure, only unlike the phellem-layers of living exogens, growing by additions to its outer side instead of being produced by a more internal "phellogen," or cork-cambium. Whilst functionally this prismatic tissue appears to have been like the phellem layer of living exogens, it is impossible to overlook the morphological resemblance between the tangential sections (fig. 95) of this tissue, and corresponding sections of the phellem layer of the bark of many exogens, in which the bast-layers form a similar network to that formed by the prismatic cells, *a*, of the above figure.

In my memoir, Part II., I have already described (p. 220) and figured (Plate 31, figs. 54–57) a small fragment of bark similar to that now described, but the specimen I then possessed left me in doubt as to which was the medullary and which the peripheral side of the example figured. This point now is no longer doubtful.

The next question is—to what plant does this bark belong? I think the answer must be, to *Sigillaria*. The prismatic or prosenchymatous layer of the bark is as I have shown in previous memoirs, common to *Sigillaria* and *Lepidodendron*, in a smaller degree to *Stigmaria*, and, as I have shown in the earlier part of this memoir, to Calamites. It is obviously a protective analogue of the corky layer of living exogens. But the characteristic feature of the example now described is found in the peculiar arrangement represented in fig. 95. In my previous memoir (*loc. cit.*) I have pointed out that a similar condition exists in association with a Diploxyloid stem now in my cabinet. I find it again in a modified shape in Syringodendroid *Sigillariæ*, and it has been described by M. RENAULT, in a most marked form, in his memoir on *Sigillaria spinulosa.*[*] In the case of the latter plant, the fragments of the bark, with its peculiar network of prosenchymatous structures, attracted the notice of the late M. BRONGNIART, who gave to it the provisional name of *Dictyoxylon*, a name which I had previously given to what is now the *Lyginodendron Oldhamium.* M. RENAULT, however, successfully demonstrated (*loc. cit.*, Plate IV., fig. 24) that BRONGNIART'S *Dictyoxylon* was merely part of the bark of his *Sigillaria spinulosa.* The elaborate and well-illustrated description of the structure of the bark of this plant by M. RENAULT shows that in all its essential features it agrees thoroughly with that which I now describe. All these facts tend to justify my conclusion that the latter is *Sigillarian*, and it would further appear probable that the peculiar network formed by the peripheral portion of the prismatic layer (which layer M. RENAULT designates the corky layer, or "couche subereuse") are characteristic of most of the *Sigillariæ.* As shown in some of my previous memoirs, the bark of *Lepidodendron* exhibits, even in its young state, the same subdivision (Phil. Trans., 1877, Plate 41, figs. 6 and 7) into the three layers found in *Sigillaria*, viz., an inner parenchyma, a median prosenchymatous layer, and a second external parenchyma. But I have not yet found in any *Lepidodendron* the peculiar reticulated arrangements of the prosenchyma which I have just described. But in this latter respect the Lepidodendra agree with the *Sigillaria elegans* of BRONGNIART.[†] The physiological conclusions which these studies justify are, I think, obvious; viz., that there are two vertical zones in the bark of these plants in which active meristem growth has gone on. In other words, there were two planes of genetic activity. One of these was at the junction of the vascular zone and the innermost bark, representing the true cambium of ordinary exogens, adding periodically, though perhaps irregularly, to the thickness of the vascular zone, and possibly also, though on this point I am more doubtful, making additions to the inner surface of the inner cortical parenchyma. The other genetic plane was a peripheral one, multiplying the cells of the superficial parenchyma, and also making additions to the exterior of the prosenchymatous analogue of the corky layer of living exogens.

The prevalence of this peculiar regular form of prismatic cellular tissue amongst these carboniferous cryptogams is a curious fact. We have seen that it prevails alike in the bark of the matured *Calamite*, and that it forms the medullary rays of the same plant. (See my memoirs, Part I., Tab. 23, fig. 8; Tab. 24, fig. 11.) We find it in *Favularia* (Memoirs, Part II., Plate 27, fig. 29), in *Lepidodendron Harcourtii* (*idem*, Plate 26, fig. 13, *i*), in *Syringodendron* (*idem*, Plate 29, fig. 42, *i*), in *Stigmaria* (*idem*, Plate 30, fig. 41, *k*; Plate 31, figs. 55-56), in the Diploxyloid *Lepidodendron* of Burntisland (Memoirs, Part III., Plate 43, fig. 17), and in *Asterophyllites* (Memoirs, Part V., Plate 1, fig. 7). I have not met with its long continuous lines of cells in any of the ferns. The fact that it constitutes a very peculiar form of medullary ray in the

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[*] 'Memoires présentés par divers savants à l'Académie des Sciences de l'Institut National de France,' tom. 22, No. 9.

[†] 'Archives du Museum,' 1839.

Calamite is curious. Without losing a certain mural arrangement, the cells, in that plant, are, as pointed out in my first memoir, like bricks standing upon their ends. This vertical elongation of the mural cells of a medullary ray is not without its living representative: I find it in sections of the wood of the ebony.

The only objects which at present remain to be described, are some remarkable ones from the Halifax nodules, found by Mr. BINNS; two of these are represented in fig. 102, imbedded in a mass of spores and other fragments of carboniferous plants. These objects consist of a central cell, surrounded by a ring of 8 or 9 somewhat obovate scales, each one of which seems to be a single cell. In two cases the central area is further subdivided (101, *a*) into a small six-sided centre, surrounded by 6 regular subdivisions; but whether these surfaces represent 7 distinct cells, or whether they are merely the superficial impressions of other cells with which they were formerly in close contact, I am unable to determine. I incline to the latter conclusion, since they appear to me to be only impressed on one surface of the area, corresponding with the centre of fig. 102, *b*. The peripheral appendages are evidently thin, because their margins often overlap each other very distinctly. That these are free objects and not mere sections of some elongated structure is obvious from their number and from the frequent way in which two of them partially overlap each other. They may possibly be some new form of sporocarp. Until we discover further information respecting them it may be convenient to recognise them by the name of *Oidospora anomala.* Their diameter is about ·0023.

I have once more to acknowledge the aid I have received from allies, old and new: Mr. BUTTERWORTH and Mr. NIELD; JOHN AITKEN, Esq., of Bacup; Mr. ISAAC EARNSHAW, Messrs. SPENCER and BINNS, of Halifax; Professor YOUNG and JOHN YOUNG, Esq., of the Glasgow University; E. WUNSCH, Esq., of Glasgow, and Professor BALFOUR, of Edinburgh, have all kindly given me valuable aid by supplying me with important specimens; whilst I am again indebted to the Messrs. PATTISON, of Manchester, for the use of their very effective marble-cutting machinery.

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PLATE 19.

Astromyelon.

Fig. 1. Transverse section of a stem of Astromyelon enlarged 14 diameters. *a*. Medulla. *b*. Vascular wedges.

Fig. 2. Longitudinal section of a branching stem enlarged 6 diameters. *a*. Medulla. *a′*, *a″*. Medulla of Branch.

Fig. 3. A small portion of fig. 2, enlarged 44 diameters, showing the junction of the medullary cells, *a*, with the innermost vessels, *b*.

Fig. 4. Obliquely transverse section of a specimen like fig. 2. *a*. Medullary cells of stem intersected transversely. *a′*. Medullary cells of branch intersected almost longitudinally.

Fig. 5. Transverse section of a stem with an unusually large medulla, *a*, and numerous primary vascular wedges, *b*, resembling those of some Calamites, but devoid of any longitudinal internodal canals. *x*, *x*. Intruded Stigmarian rootlets. Magnified 6 diameters.

Fig. 6. Tangential section of a part of a primary vascular zone exhibiting the vascular laminæ, (*b*) separated by primary (*c′*) and secondary (*c*) medullary rays.

Fig. 7. Transverse section of a stem in which the bark (*d*) is preserved, and also exhibiting the bundle of enlarged vessels occupying the medullary angle of each primary vascular wedge.

Calamites.

Fig. 8. Transverse section of a very young Calamite enlarged 26 diameters. *b*. Medulla. *e*. Longitudinal internodal canals. *h*. Cortex.

Fig. 9. Similar section to fig. 8, but deprived of its cortex. Enlarged 26 diameters.

Fig. 10. Similar section to fig. 8, but somewhat more advanced in development. *a*. A fissure in the medulla indicating the commencing formation of a *fistular* medulla. Enlarged 26 diameters.

Fig. 11. Similar section to fig. 10, but decorticated, and with the fistular medullary canals (*e*); further enlarged. *b*. Medulla.

PLATE 20.

Fig. 12. Transverse section of a young decorticated stem in which also the fistular medullary cavity, *a*, is yet more enlarged than in fig. 10. Enlarged 26 diameters. *c*. Primary medullary rays. *e*. Internodal canals. *f*. Vascular wedges.

Fig. 13. Transverse section of a larger stem in which the vascular wedges (*f*) are in the same stage of development as in fig. 12, but in which the fistular medullary cavity (*a*) is larger. *h*. Cortex. Magnified 26 diameters.

Fig. 14. Transverse section of a large Calamite. *a*. Fistular medullary cavity. *b*. Thin layer of medullary cells. *f*. Primary vascular wedges merging into a continuous vascular structure towards their peripheral extremities. *h*. Thick, shattered layer of bark chiefly composed of prismatic prosenchyma. Two-thirds natural size.

Fig. 15. Vertical section of the specimen, fig. 14, passing through a node at *n*. Reference letters as in fig. 14. Two-thirds natural size.

Fig. 16. Radial vertical section of the vascular cylinder of fig. 14. *d*. Secondary medullary rays. *g*. Vessels. Enlarged 14 diameters.

Fig. 17. Small portion of another radial section, like fig. 16. *d*. Secondary medullary rays. *g*. Peculiarly contorted vessels. Enlarged 20 diameters.

Fig. 18. Transverse section of a small portion of the outer bark, composed of cells of prismatic prosenchyma arranged in lines radiating from within outwards. Enlarged 26 diameters.

Fig. 19. Radial section of fig. 18. Enlarged 14 diameters.

Fig. 20. Tangential section of fig. 18. Enlarged 32 diameters.

Fig. 21. Portion of a tangential section of the same bark, with a lenticular mass of parenchyma passing through it radially. Enlarged 10 diameters.

Fig. 23. Tangential section of the node of a vascular zone of another Calamite intersected near its medullary surface. *c*, *c′*, *c″*, *c‴*. Primary medullary rays separating the primary vascular wedges, *f*. *l*. Clusters of small cells located at the upper nodal extremity of each primary medullary ray. *m*, *m″*. Small lenticular areas usually isolated upon the node, as at *m*, but in one instance, *m″*, connected with the primary medullary ray, *c‴*. Enlarged 8 diameters.

Fig. 24. Similar section to fig. 23, and from the same segment of the same Calamite, but made nearer to the cortical surface of the vascular cylinder. The cellular masses, *l*, at the upper extremities of the primary medullary rays, fig. 23, *c′*, now appear as isolated lenticular areas, *l*, enclosed within the coalesced vascular wedges *f*. The primary medullary rays with which they are connected in fig. 23 have disappeared, and are only represented by dark vertical lines, similar to those shown at *c*. *m*. Verticil of lenticular cellular (?) areas, apparently identical with those at fig. 23, *m*. Enlarged 8 diameters.

Fig. 25. One of the lenticular areas, *l*, of fig. 24, further enlarged.

PLATE 21.

Fig. 26. Tangential section from the node of a large Calamite cutting, at *m*, transversely through the medulla of a developing branch. Enlarged nearly 6 diameters.

Fig. 27. Radial longitudinal section of another part of the node of the Calamite, fig. 26, passing longitudinally through the medulla of a lateral branch. *a*. Fistular medullary cavity of the primary stem. *b*. Medullary cells of the parent stem. *g*. Vessels of the same. *m*, *m′*. Parenchyma of the developing branch, originating in the pith of the parent stem at *m′*, and passing outwards. Enlarged nearly 6 diameters.

Fig. 28. Tangential section across the node of a decorticated Calamite, about 1·25 in diameter, and with a vascular cylinder about ·25 in thickness. *c.* Primary medullary rays. *f.* Primary vascular wedges. *m.* Small lenticular cellular (?) areas, apparently identical with fig. 23, *m.* In the middle of the section is a transverse section of a small emerging branch, having a central cellular medulla, surrounded by a cylinder of radiating lamellæ of vascular tissue. Enlarged 20 diameters.

PLATE 20.

Fig. 29. Part of a tangential section of a node of the same Calamite as fig. 28. The cellular area, *m,* is the medullary extremity of a branch intersected transversely, and a similar section of the peripheral part of which is almost identical with fig. 26. *m′, m′.* Enlarged *secondary* medullary rays. Enlarged 33 diameters.

PLATE 21.

Fig. 30. A Calamite in shale with the base of a large lateral branch. Natural size.

Fig. 31. Lower extremity of the sandstone cast of the fistular medullary cavity of a Calamite with two verticils, *l, l′,* of the casts of the infranodal medullary canals passing through the decomposed carbonaceous matter of the vascular zone, *f, f.* Slightly enlarged.

Fig. 31A. Vertical section through fig. 31B intersecting the two fistular medullary canals. *a.* Medullary canal of primary stem. *a′.* Medullary canal of branch. *f.* Vascular zone of primary stem. *f′.* Vascular zone of branch. *f″.* Vascular area intermediate between the two fistular medullary canals, *a* and *a′,* fig. 31. Two-thirds natural size.

Fig. 31B. Transverse section of a decorticated Calamite giving off obliquely a lateral branch. *a.* Medullary canal of primary stem. *a′.* Medullary canal of the branch *m.* *f.* Vascular zone of primary stem. *f′.* Vascular zone of branch with its primary vascular wedges separated by the primary cellular medullary rays. Two-thirds natural size.

Asterophyllites.

Fig. 32. Obliquely transverse section of an Asterophyllites passing through a node. *c.* Primary vascular axis. *d.* Exogenous vascular zone, consisting of a single layer of vessels. *g.* Space left vacant by the disappearance of the inner bark. *k.* Outer bark. *l.* Vacant canals left by the destroyed vascular bundles of a corresponding number of verticillate leaves. *m, m.′* Leaves. *x.* Triangular vascular bundle going off to a lateral branch.

PLATE 22.

Lepidodendron.

Fig. 33. Transverse section of part of a stem of *Lepidodendron selaginoides.* *c.* Medullary vascular zone. *d.* Exogenous vascular zone. *g.* Inner bark. *n.* Inner parenchymatous portion of outer bark. *m.* Foliar vascular bundles. *m′.* Foliar vascular bundle, issuing from the exterior of the medullary vascular zone *c*, and passing outwards through the exogenous vascular zone *d.* Enlarged 14 diameters.

Fig. 34. Longitudinal section of a branch of *Lepidodendron selaginoides.* *a.* Medullary axis composed of intermingled cells and vessels, the latter alone composing the periphery of the structure. *d.* Exogenous vascular layer. *g.* Inner parenchymatous bark. *h.* Middle parenchymatous bark. *i.* Prosenchymatous layer of the bark. *l.* Persistent bases of leaves. *m.* Vascular leaf-bundles. Enlarged nearly 3 diameters.

Fig. 35. Portion of fig. 34 further enlarged. *c.* Vessels of the medullary axis. *d.* Exogenous vascular zone. *g.* Inner bark. *m.* Foliar vascular bundle passing outwards through the exogenous zone. Enlarged 14 diameters.

PLATE 21.

Fig. 36. Tangential section of a portion of the exogenous vascular zone of fig. 34. *e.* Vessels of the exogenous zone. *f.* Medullary rays. *m, m.* Lenticular openings through which the foliar vascular bundles passed outwards through the exogenous zone. Enlarged 16 diameters.

Fig. 37. Portion of the section, fig. 34. Enlarged 10 diameters. *c.* Vessels of the medullary axis. *d.* Exogenous vascular layer. *g, g.* Inner parenchymatous bark. *m, m′.* Two foliar vascular bundles.

PLATE 22.

Fig. 38. Prosenchymatous cells from the sporangium wall of a *Lepidostrobus* from Halifax. Enlarged 106 diameters.

Figs. 39 to 47. Various states of the mother or sister cells and the spores of the Halifax *Lepidostrobus.* Enlarged 106 diameters.

Fig. 48. Three microspores from a crushed *Lepidostrobus* from Halifax. Enlarged 106 diameters.

Figs. 49–50. Clusters of microspores from two Lepidostrobi from near Oldham. Enlarged 106 diameters.

Fig. 51. Similar cluster of four spores from the recent *Lycopodium alpinum.* Enlarged 106 diameters.

Fig. 52. Spore like figs. 44 and 47, but exhibiting the cell, *d*, of fig. 46 crossing the disk of the spore at *d′*.

Fig. 53. Transverse section of the *Lepidostrobus*, from which the spores, figs. 39 to 47 were derived. *a*. Vascular axis displaced. *b*. Prosenchymatous cells of the outer cortical layer. *c, c′, c″*. Sporangiophores. *d*. Sporangia with spores in groups of 4, and mother or sister cells. *e*. Sporangium walls. Enlarged 12 diameters.

Fig. 54. Slightly oblique tangential section of the same *Lepidostrobus* as fig. 53, made nearly in the plane of the outer surface of the vascular axis of the strobilus. Enlarged 5 diameters.

Fig. 55. Oblique tangential section of the same made a little external to fig. 54. Enlarged 4 diameters.

Fig. 56. Longitudinal section of a portion of the same. Enlarged 14 diameters.

Fig. 57. A single sporangium of the same *Lepidostrobus*, with numerous clusters of tetraspores and sister (?) cells. Enlarged 50 diameters.

PLATE 23.

Figs. 58, 59 and 60. Macrospores from Halifax. Enlarged 43 diameters.

Figs. 61 and 62. Similar macrospores. Enlarged 100 diameters.

Fig. 63. Similar macrospore, but with numerous unbranched peripheral appendages. Enlarged 214 diameters.

Fig. 64. Three macrospores enclosed within their sporangium. Enlarged 50 diameters.

Fig. 64*. Peduncular appendage like those (*d* and *e*) of the two lower macrospores of fig. 64, and at *d, e,* in figs. 65 and 66. Enlarged 40 diameters.

Figs. 65-66. Two macrospores containing endospermic cells. Enlarged 43 diameters.

Fig. 66A. Macrospore containing endospermic cells of uniform size. Enlarged 33 diameters.

Fig. 66B. Similar macrospore to fig. 66A, but with the endospermic cells of various sizes. Enlarged 33 diameters.

Fig. 66C. Macrospore filled with parenchymatous cells.

Fig. 67. Transverse section of a remarkable conceptacle. Enlarged 50 diameters.

Fig. 68. Segment of the peripheral wall of fig. 67. Enlarged 214 diameters.

Fig. 69. A crushed specimen of the same conceptacle.

Fig. 69A. Another specimen of the same conceptacle, in which the central structure, 67, *d*, is seen to be occupied by a mass of parenchymatous cells. Enlarged 66 diameters.

Fig. 70. Two peripheral appendages from a macrospore like figs. 58–66, *apparently* consisting of two layers of tissue.

Fig. 71. A macrospore with unbranched peripheral appendages. Enlarged 100 diameters.

Fig. 72. A very small macrospore (?) with trifid peripheral appendages. Enlarged 214 diameters.

Fig. 73. A minute macrospore (?). Enlarged 214 diameters.

Fig. 74. A minute macrospore (?) resembling fig. 73, but with shorter subdivided peripheral appendages. Enlarged 214 diameters.

Fig. 75. A peculiar conceptacle filled with large cells. Enlarged 140 diameters.

Fig. 75A. A similar example to fig. 75, enlarged 100 diameters, but without the contained cells, and exhibiting the cellular areolation of the wall bounding the central cavity.

Fig. 75B. Transverse section of another example of the same. Enlarged 100 diameters.

PLATE 24.

Fig. 75C. Another example, but containing a mass of parenchyma. Enlarged 100 diameters.

Fig. 75D. Four cells from the part, *a*, of the parenchyma of fig. 75C. Enlarged 400 diameters.

Fig. 76. A similar cavity to fig. 75A. Enlarged 214 diameters.

Fig. 76A. A transverse section of a cellular conceptacle. Enlarged 214 diameters.

Fig. 77. Microspores from Halifax, a little larger than those represented in fig. 43. Enlarged 216 diameters.

Fig. 78. Transverse section of a conceptacle similar to fig. 76A, but with narrower peripheral cells. Enlarged 214 diameters.

Fig. 78A. One of the peripheral cells of fig. 78. Enlarged 866 diameters.

Rachiopteris gleiche (?) ; *Chorionopteris* of CORDA.

Fig. 79. Part of the transverse section of a Petiole.

Rachiopteris cylindrica.

Fig. 80. Transverse section. Enlarged 33 diameters.

Figs. 81, 82, and 83. Transverse sections of three successively smaller stems. Enlarged 33 diameters.

Fig. 84. Portion of the cortical layer, *b*, of fig. 82. Enlarged 143 diameters.

Fig. 85. The same section as fig. 83. Further enlarged to 143 diameters.

Fig. 86. Longitudinal section of a stem like fig. 80. Enlarged 40 diameters.

Fig. 87. Section of a stem giving off a lateral branch. Enlarged 33 diameters.

Fig. 88. Transverse section of a stem found in the same slide as figs. 80 and 87.

Cordaites (?).

Fig. 89. Portion of an epidermis, probably of *Cordaites*. Enlarged 360 diameters

PLATE 25.

Lyginodendron (?) *anomalum.*

Fig. 90. Transverse section of the vascular zone of a stem from Arran. Enlarged 14 diameters.

Fig. 91. Part of fig. 90. Further enlarged to 50 diameters.

Fig. 92. Tangential section of the same stem. Enlarged 14 diameters.

Sigillarian or Lepidodendroid Bark.

Fig. 93. Transverse section of the outermost bark. Enlarged 8 diameters.

Fig. 94. Radial vertical section of fig. 93. Enlarged 8 diameters.

Fig. 95. Tangential vertical section of fig. 93, made in a line between the two stars. Enlarged 8 diameters.

Fig. 96. Transverse section of a fragment from the innermost portion of the same specimen. Enlarged 32 diameters.

Fig. 97. Tangential section of fig. 96. Enlarged 32 diameters.

Fig. 98. Transverse section of a portion of fig. 93, made in the line of *a*, *a*. Enlarged 32 diameters.

Fig. 99. Tangential section of fig. 98. Enlarged 32 diameters.

Fig. 100. Radial vertical section of fig. 98. Enlarged 32 diameters.

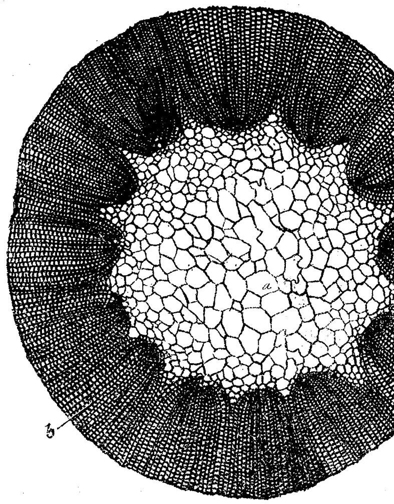
Fig. 101. Small portion of fig. 95. Enlarged 16 diameters.

Oidospora anomala.

Fig. 102. Unknown bodies. Enlarged 360 diameters.

Volkmannia parvula.

Fig. 103. Transverse section. Enlarged 54 diameters.



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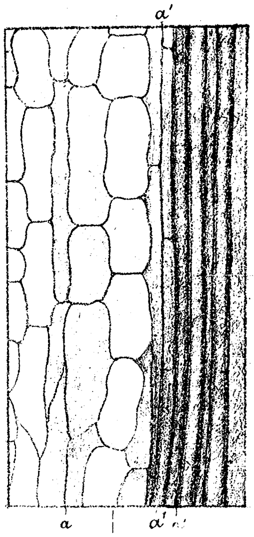

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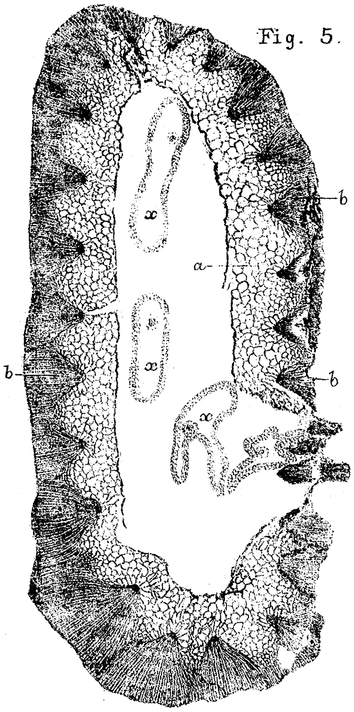

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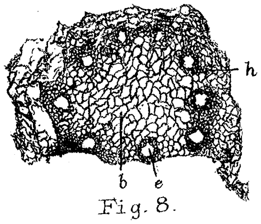


Fig. 8.

Fig. 4.

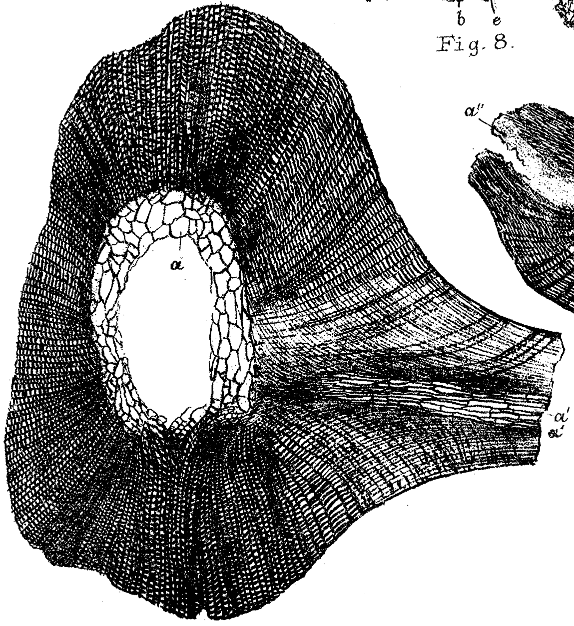
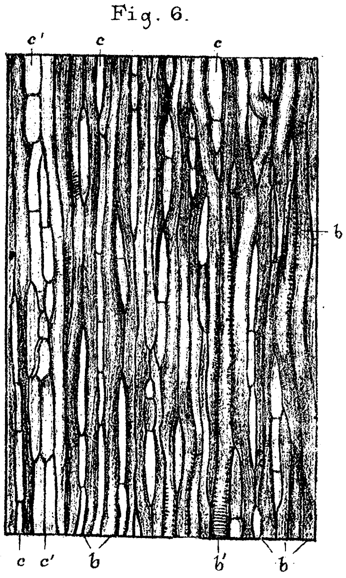


Fig. 2.

Fig. 6.



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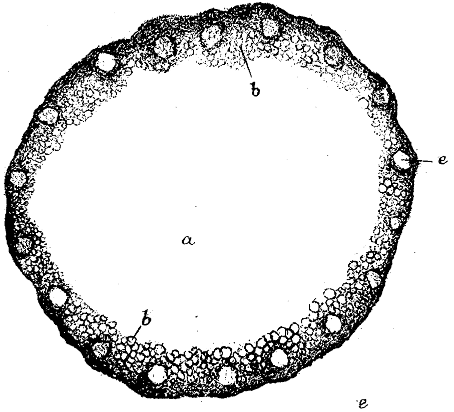

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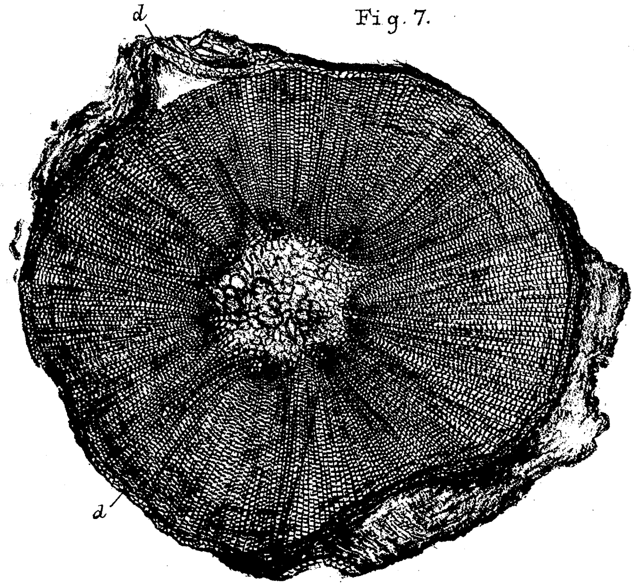

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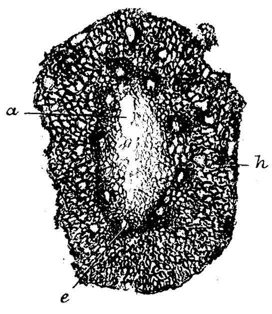

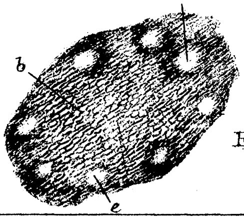

Fig. 9.

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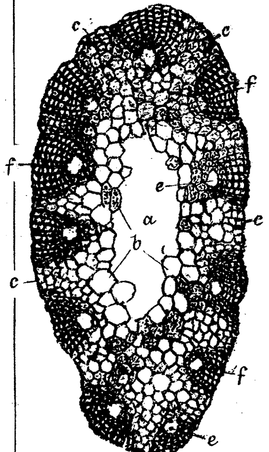
Fig. 12.



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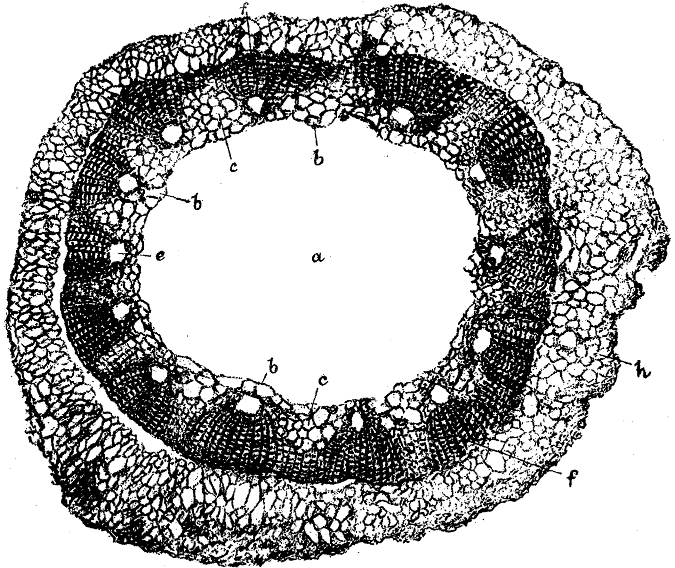

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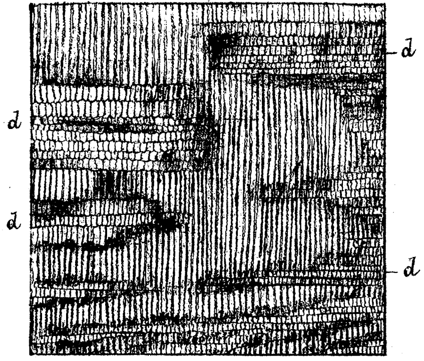

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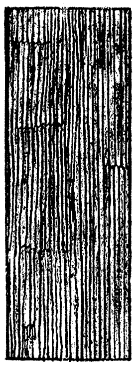

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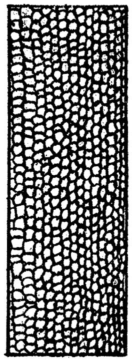
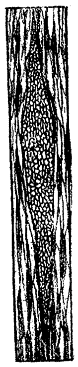


Fig. 20

Fig. 21.



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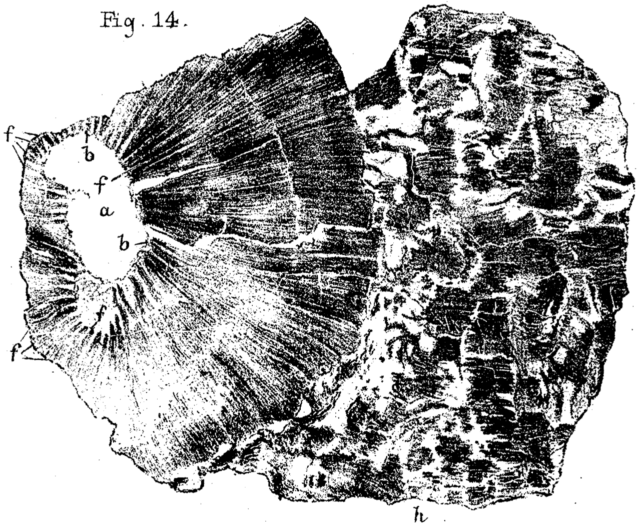

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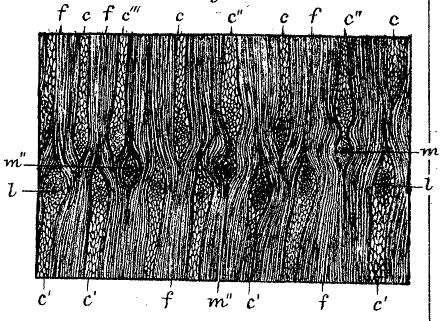

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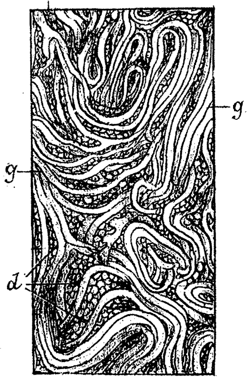

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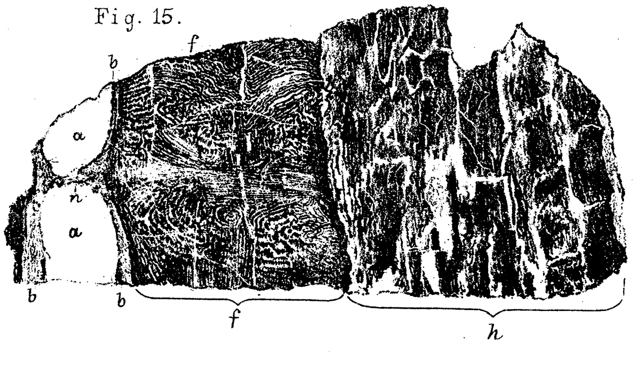

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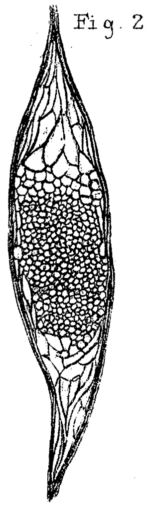

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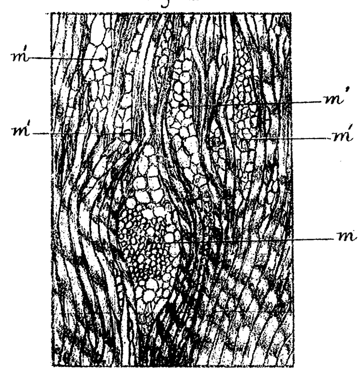

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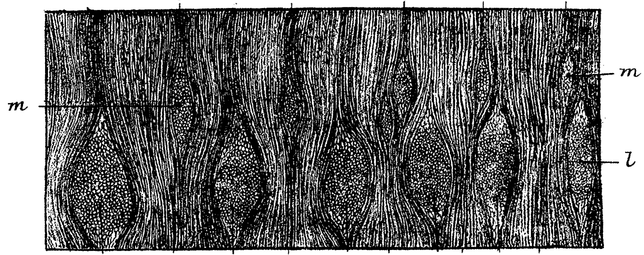

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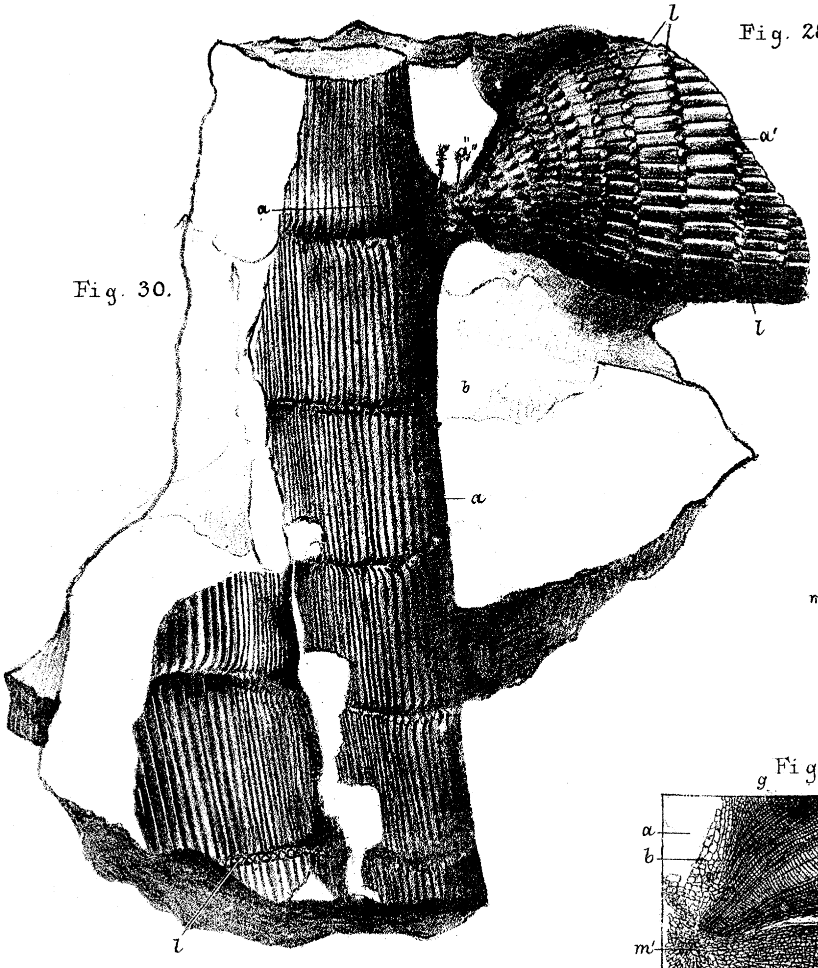
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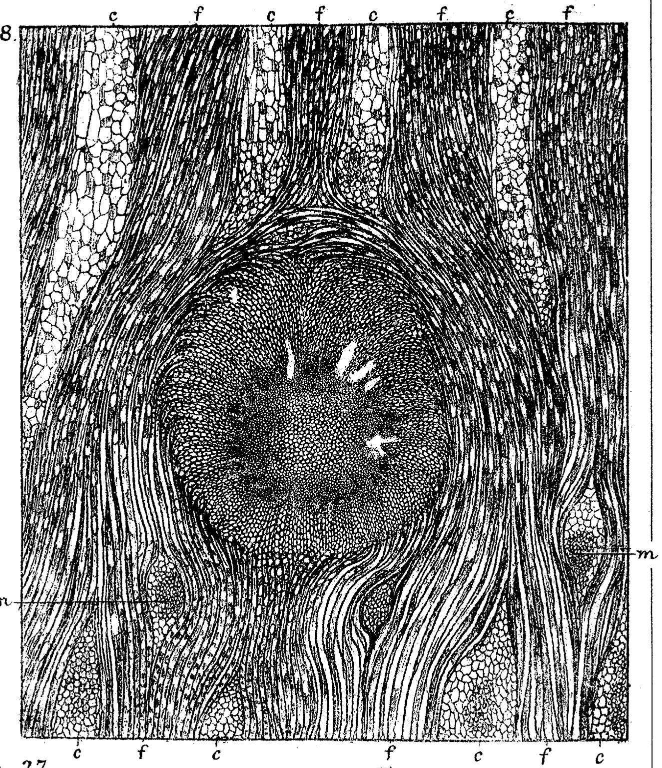
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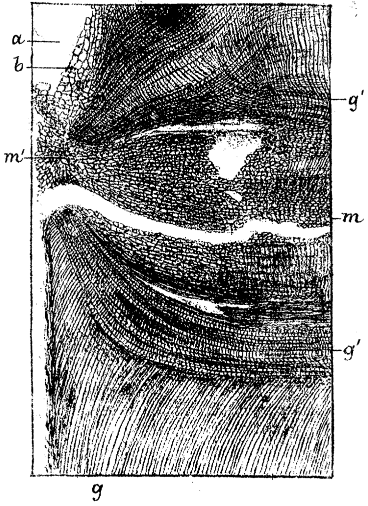
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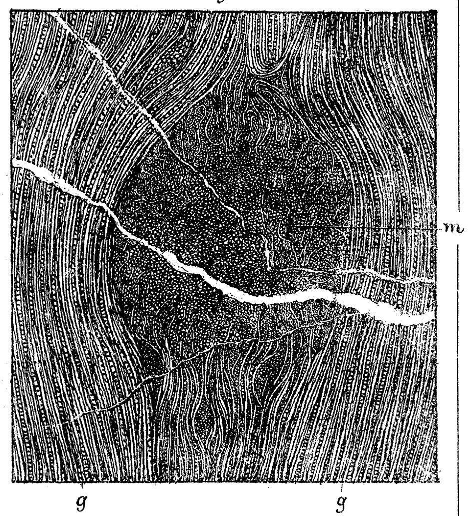
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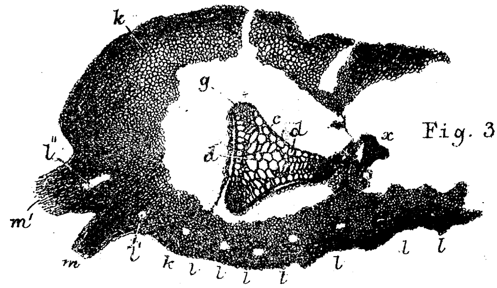
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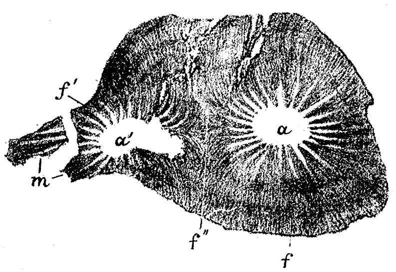
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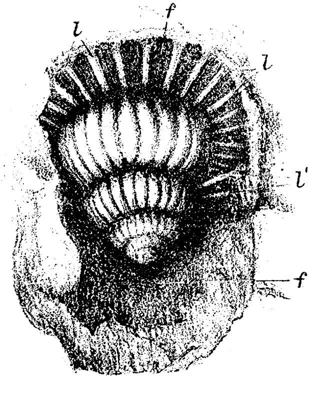
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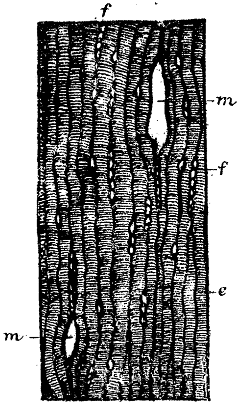
Fig. 31A.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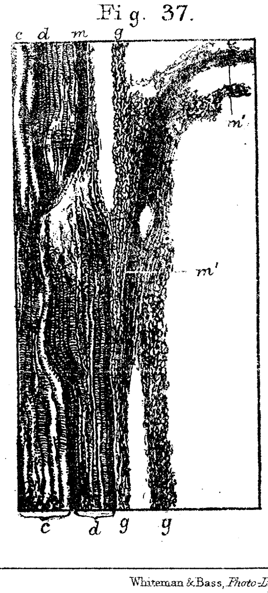
Fig. 37.

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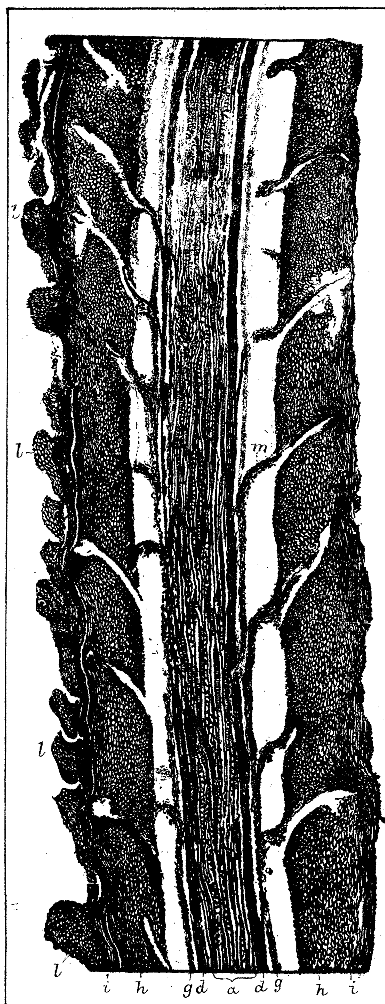

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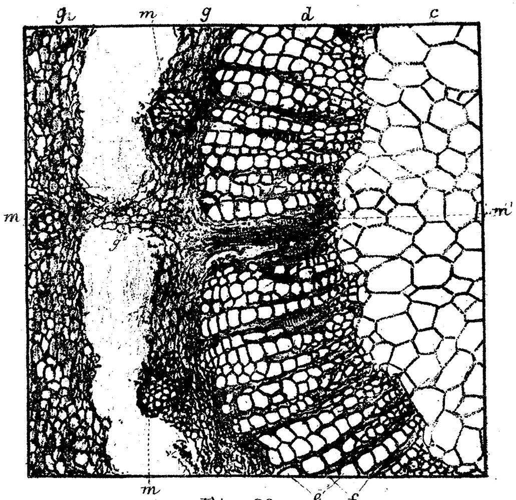

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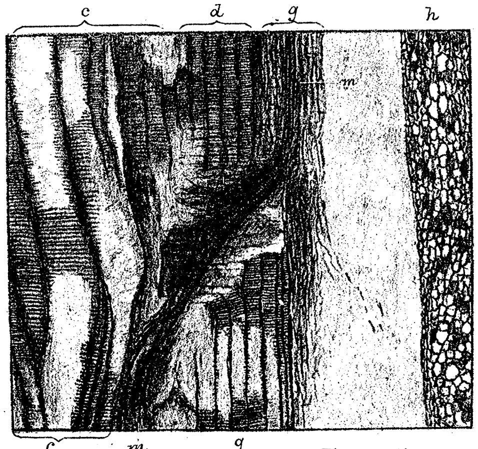

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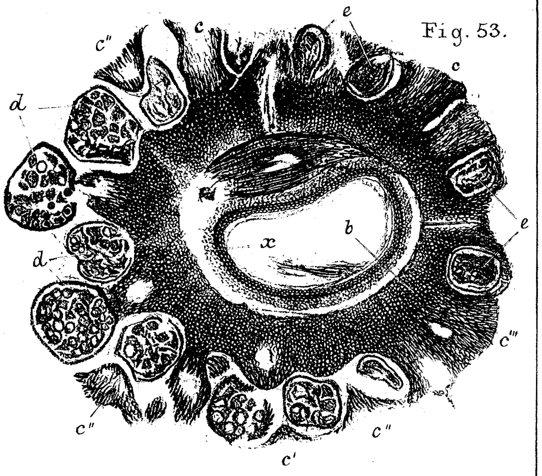

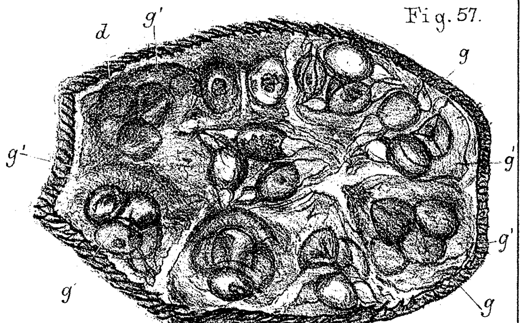

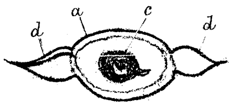

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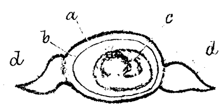

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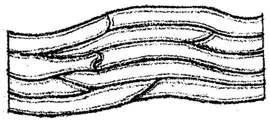

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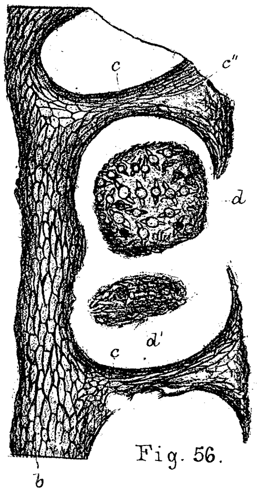

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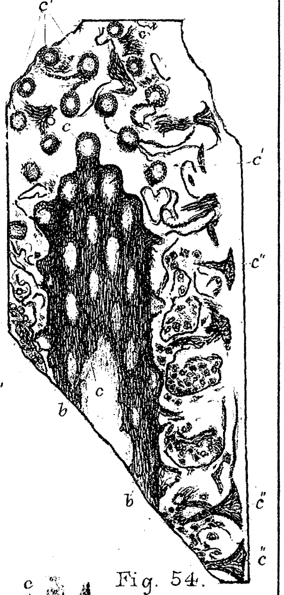
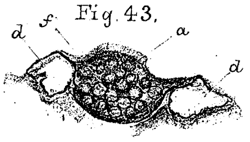
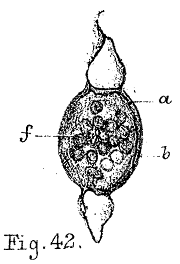


Fig. 54.

Fig. 43.





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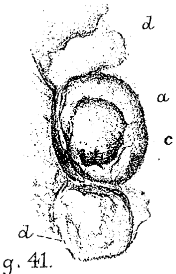

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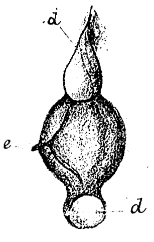

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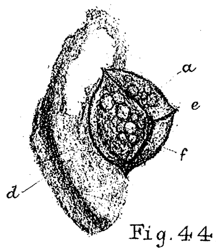

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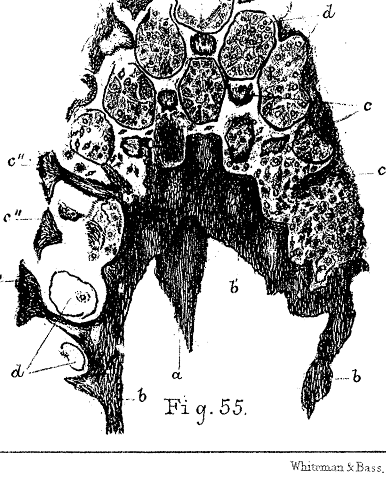

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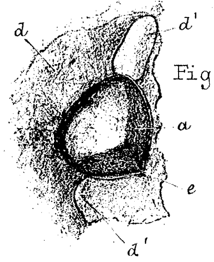

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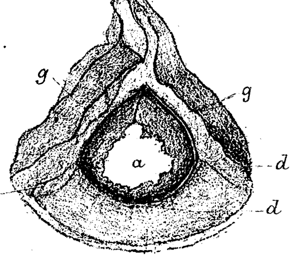
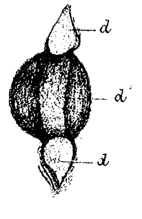


Fig. 46.

Fig. 50.

Fig. 51.



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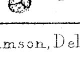

Fig. 48.

Fig. 49.

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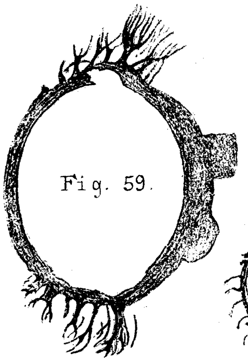
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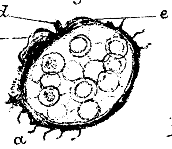
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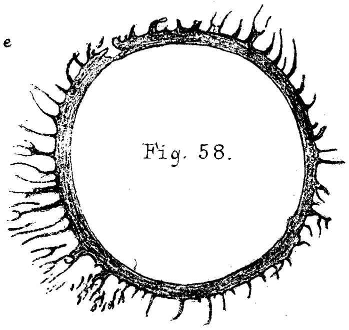
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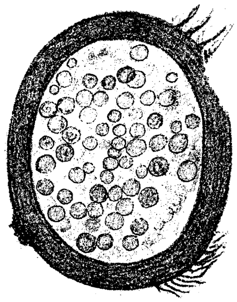
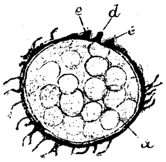


Fig. 66A.


Fig. 71.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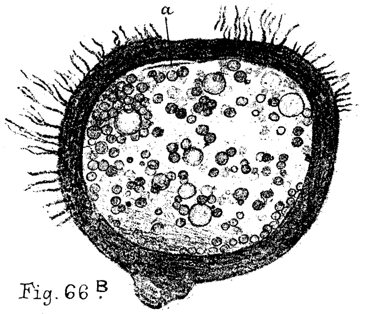
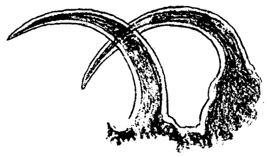


Fig. 66B.


Fig. 74


Fig. 73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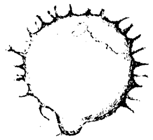
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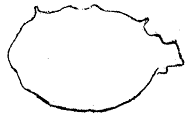
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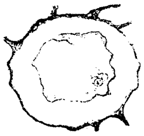
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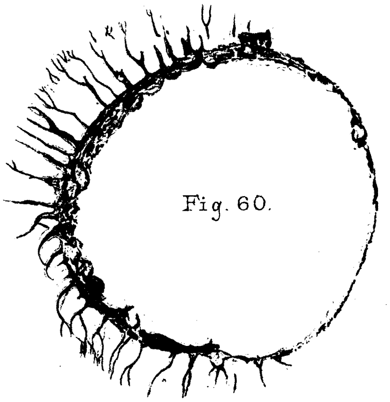
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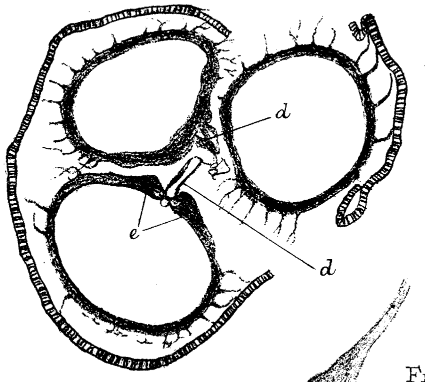
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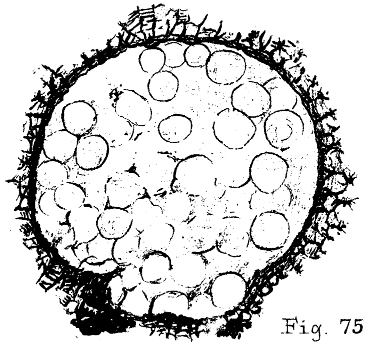
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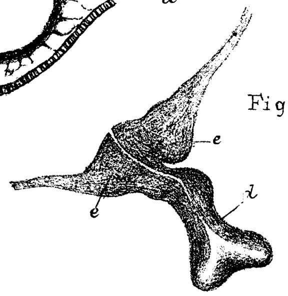
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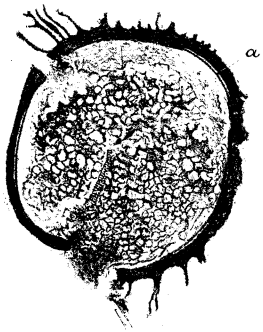
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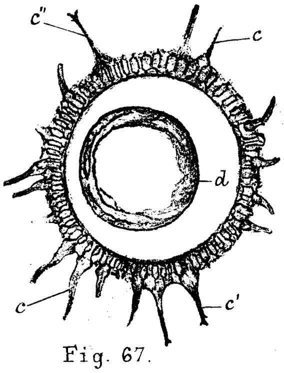
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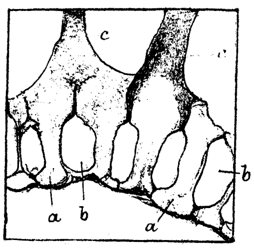
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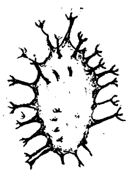
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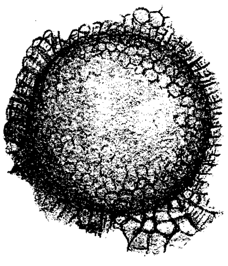
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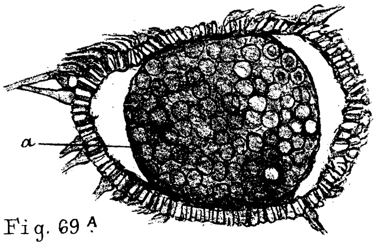
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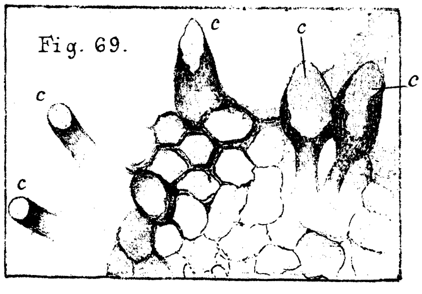
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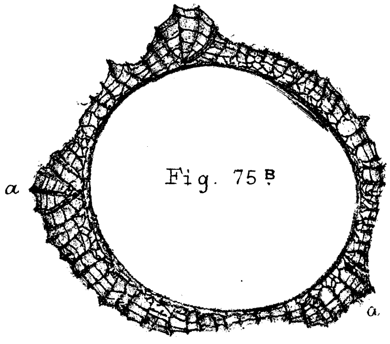
Fig. 75B.

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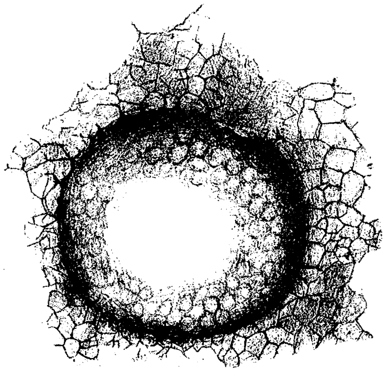
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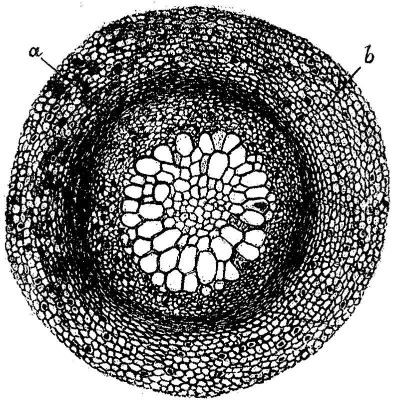
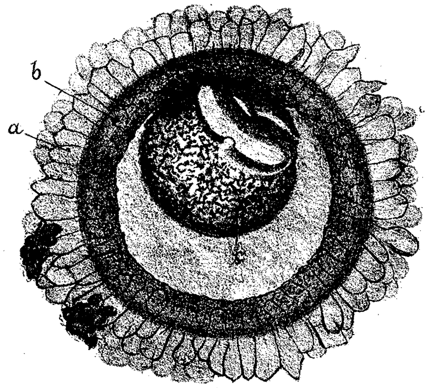


Fig. 80.


Fig. 77.



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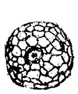
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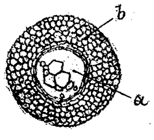

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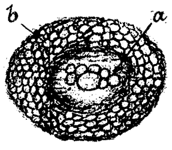

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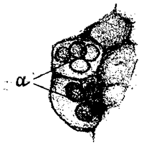

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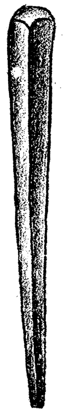
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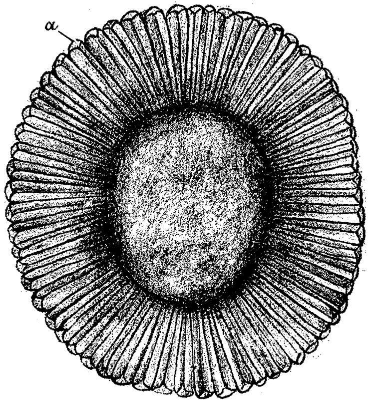

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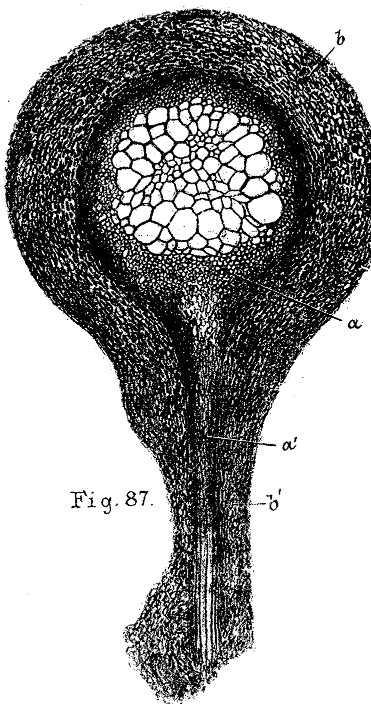

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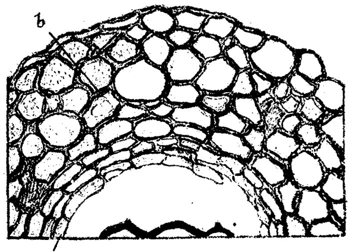

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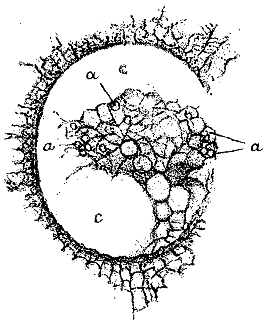

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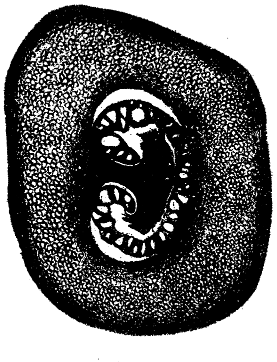
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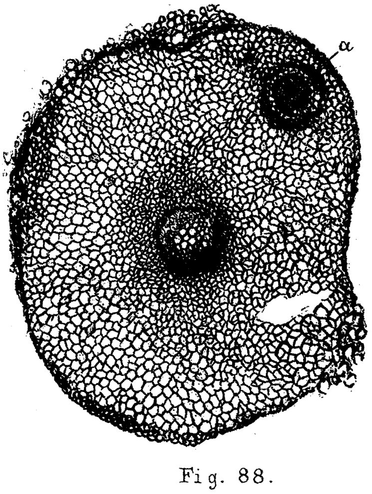
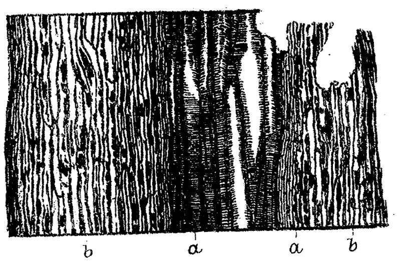


Fig. 88.

Fig. 86.



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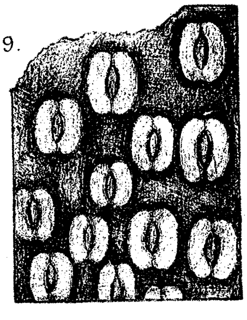

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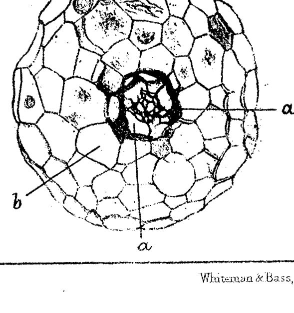

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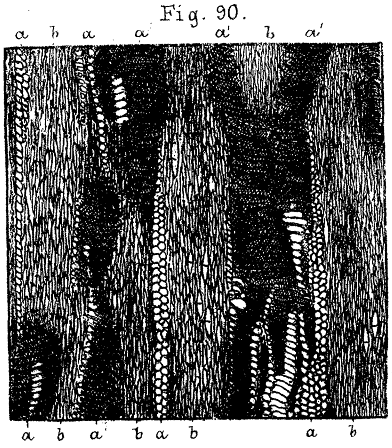
Fig. 90.



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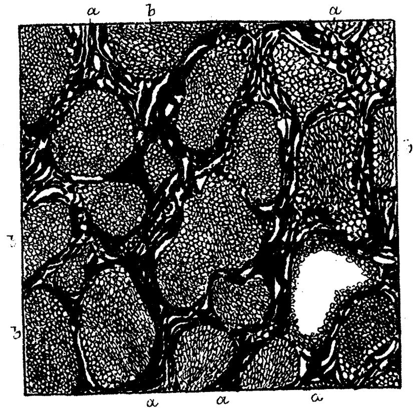

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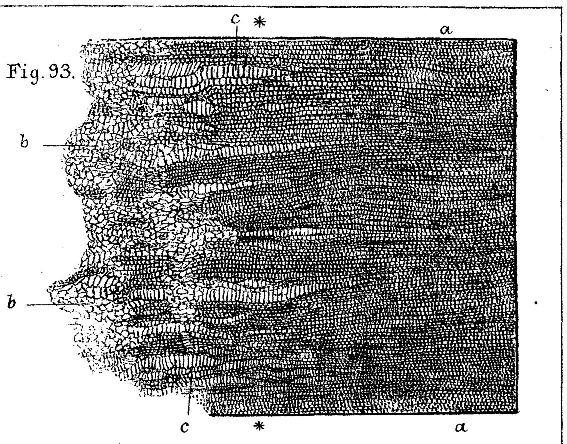

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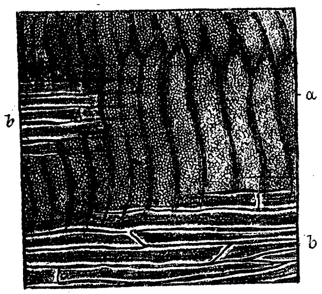

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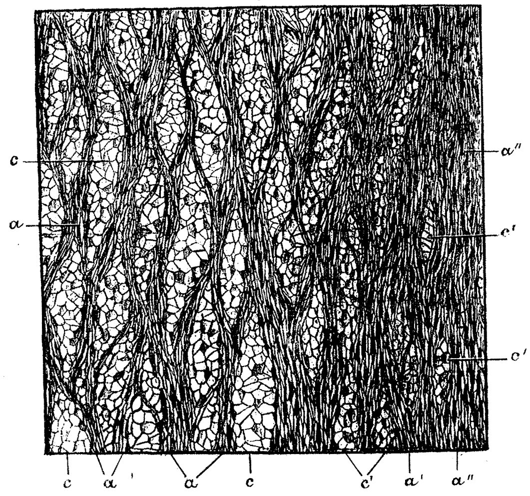

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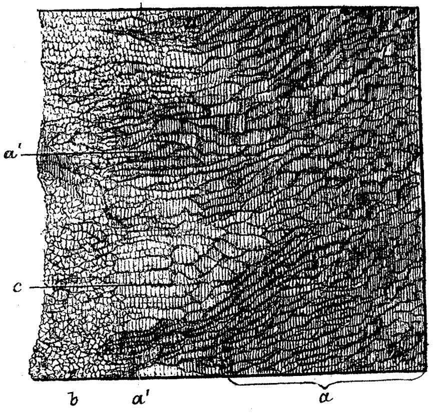

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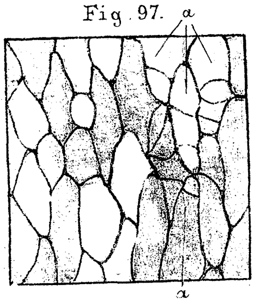

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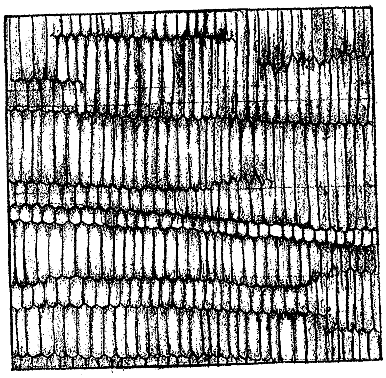

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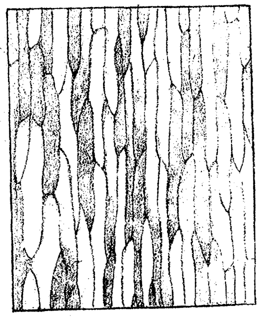

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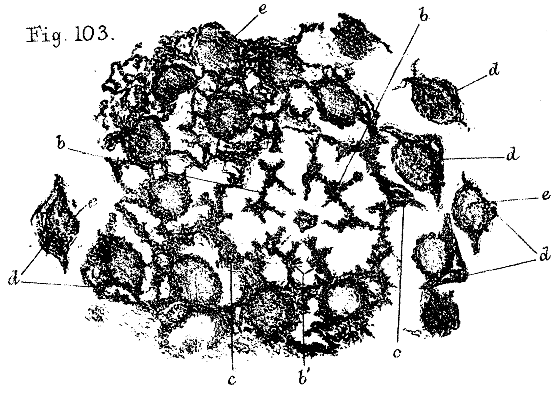

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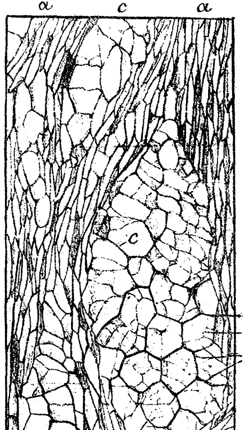

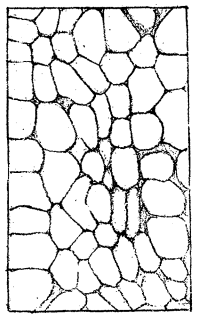

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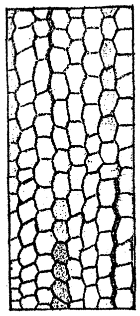

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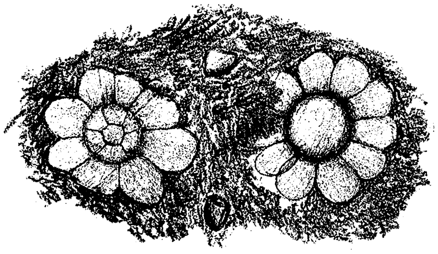

Fig. 102.

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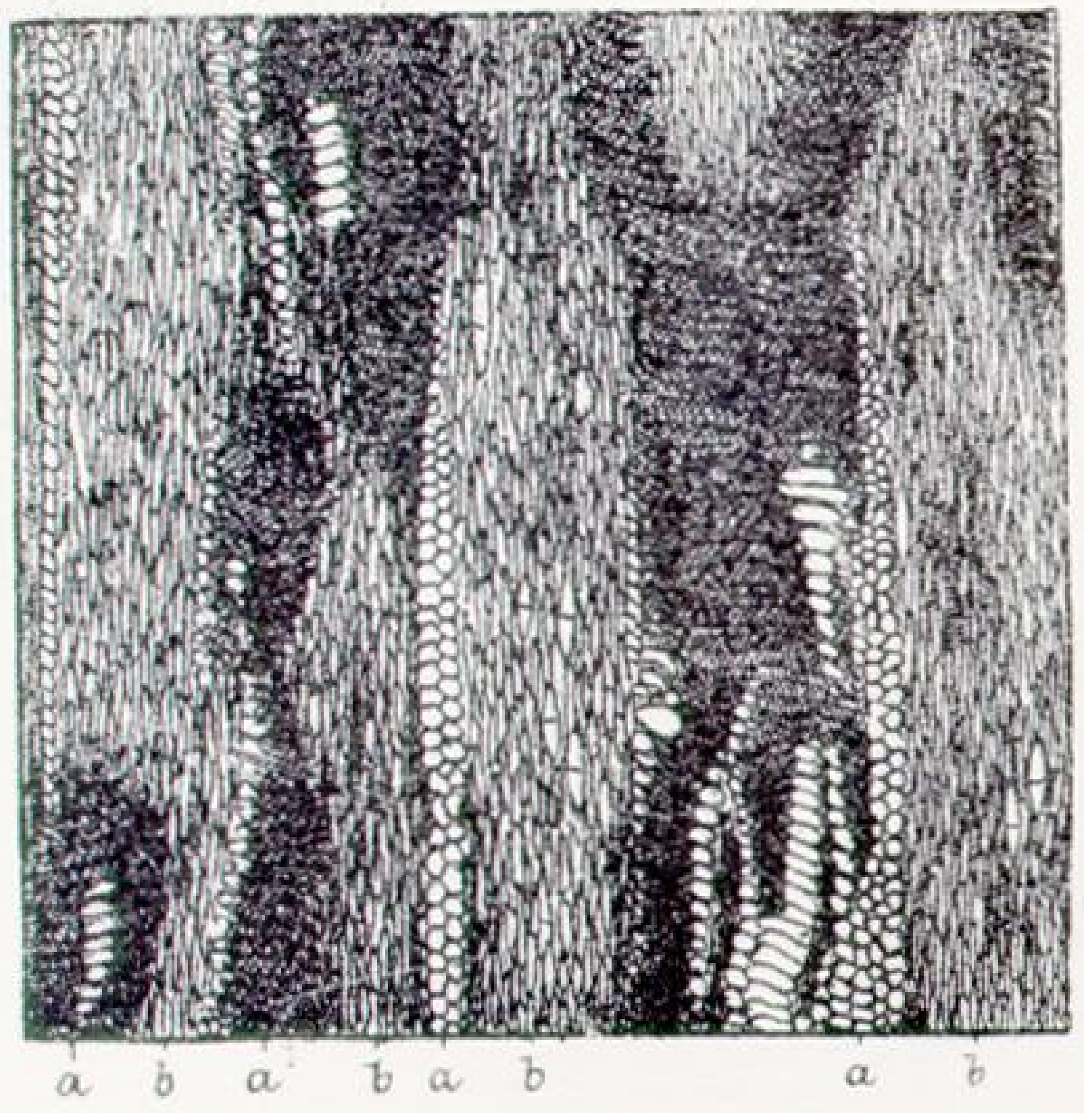
Fig. 90.



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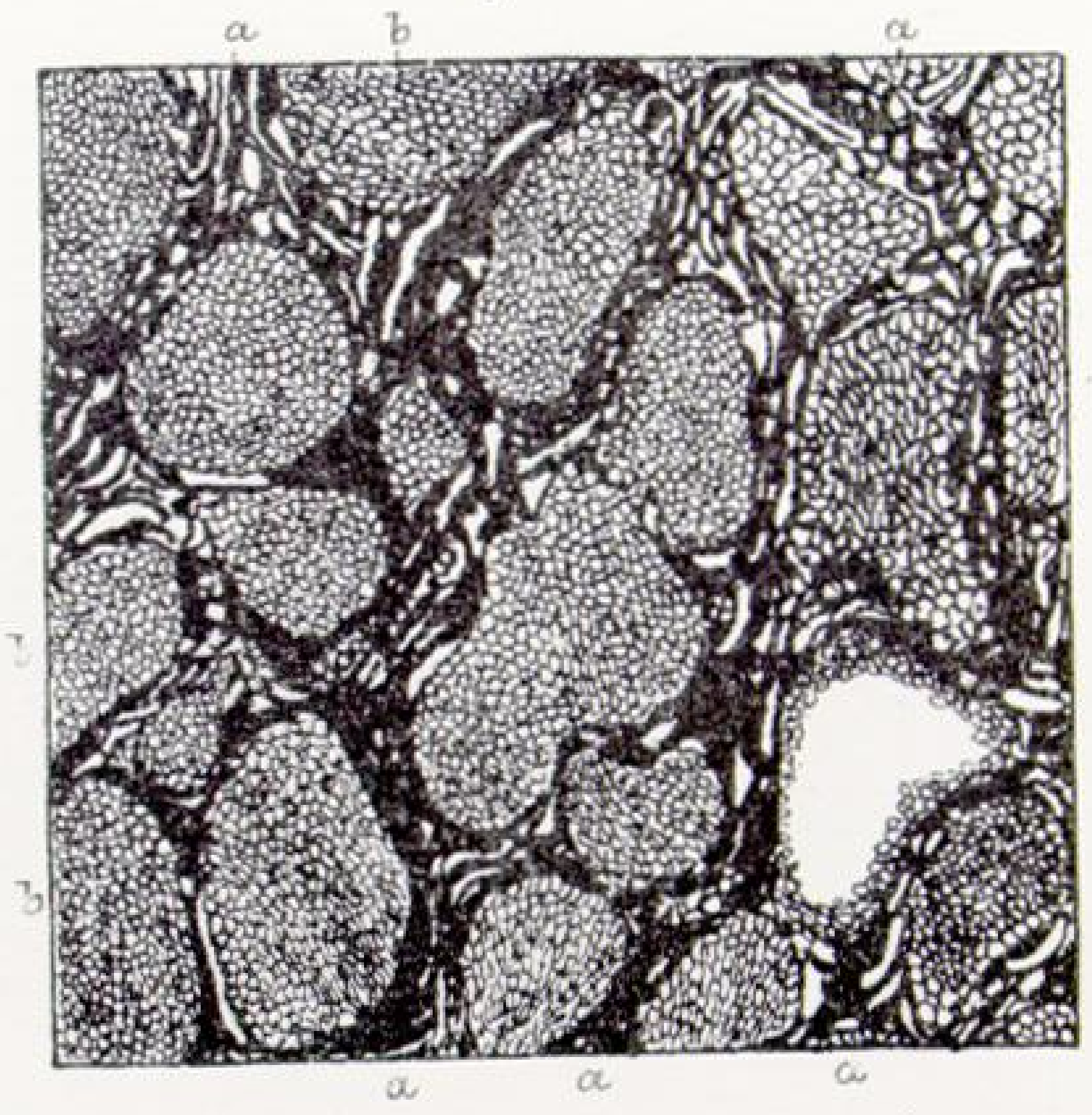

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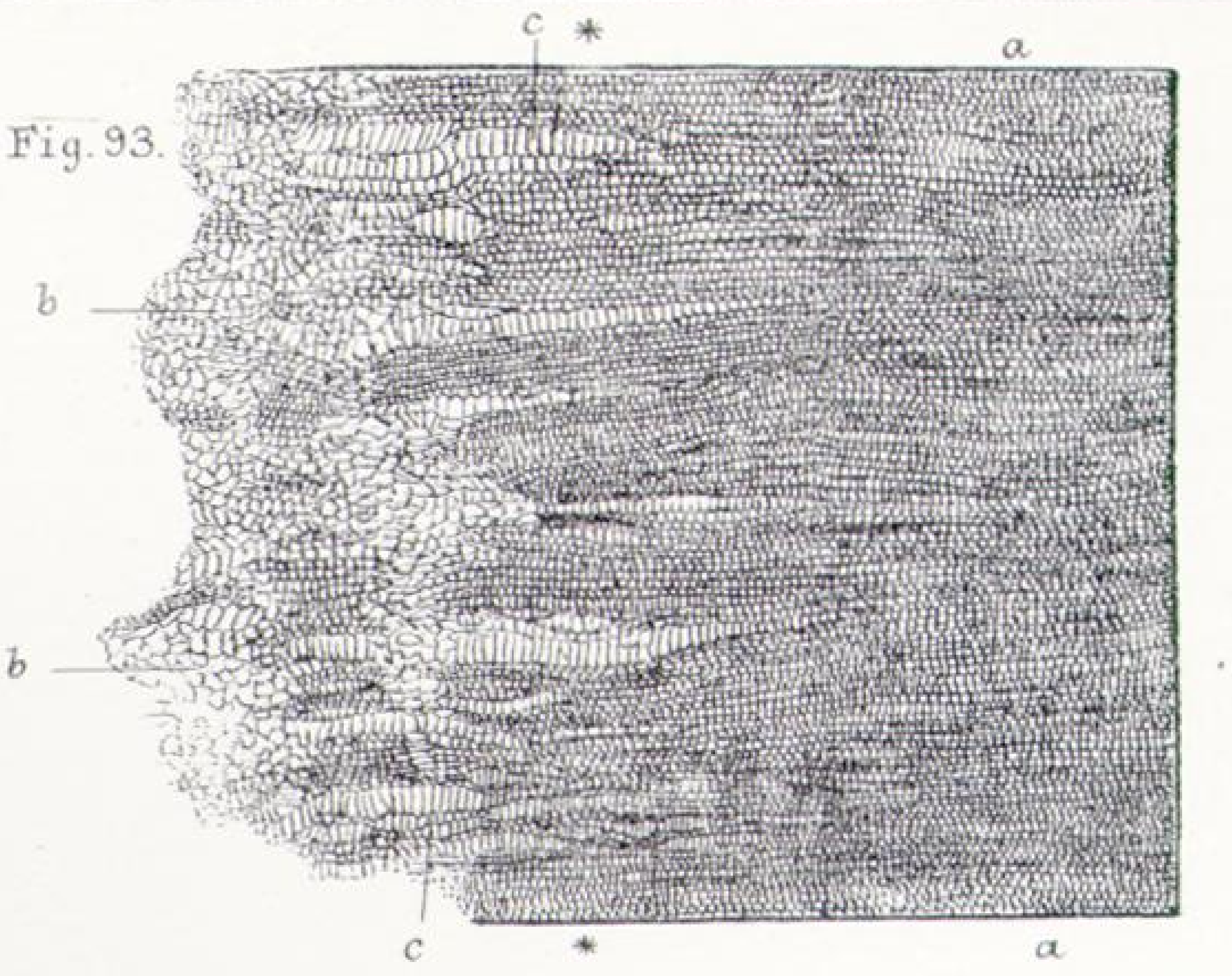

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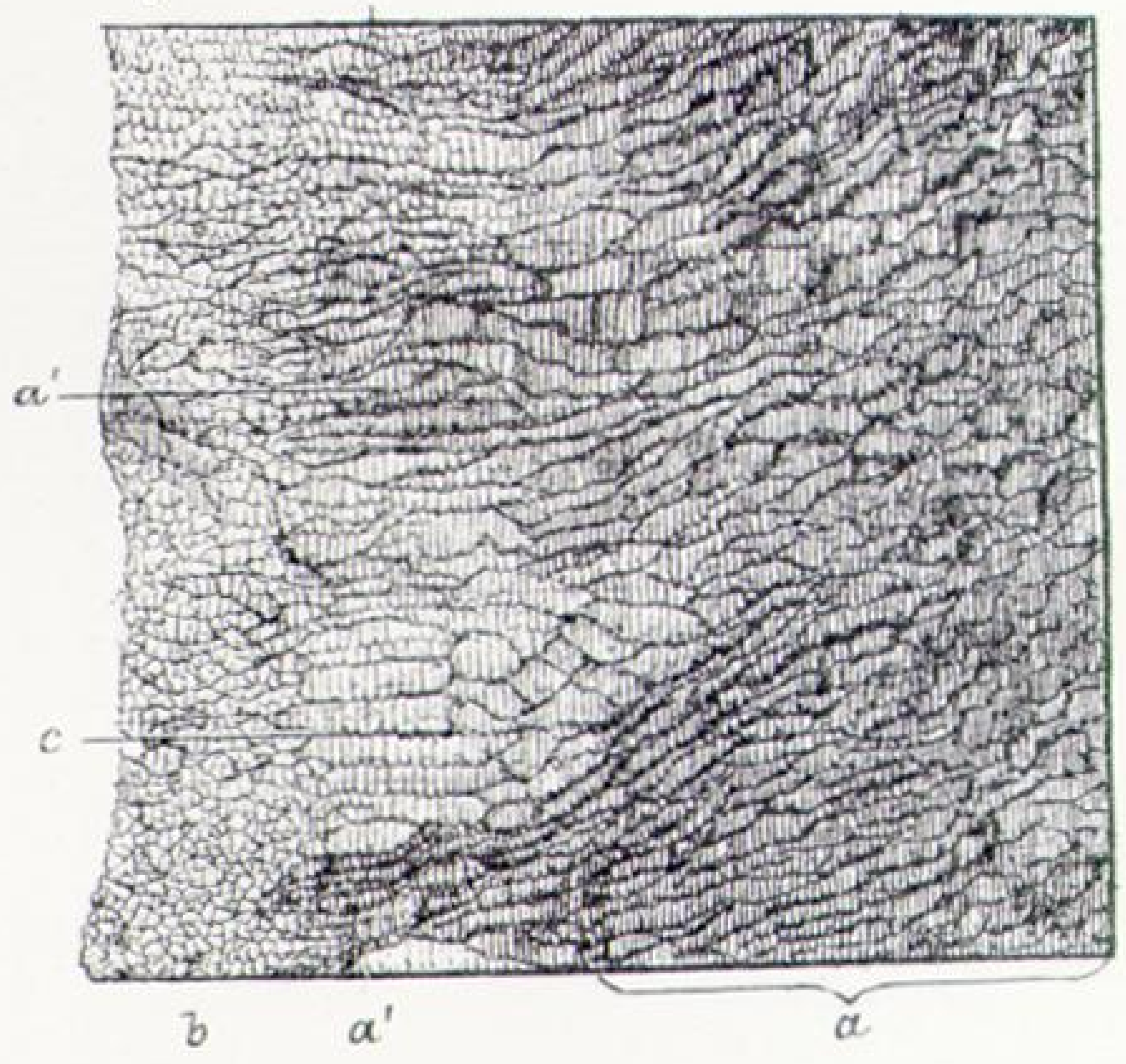

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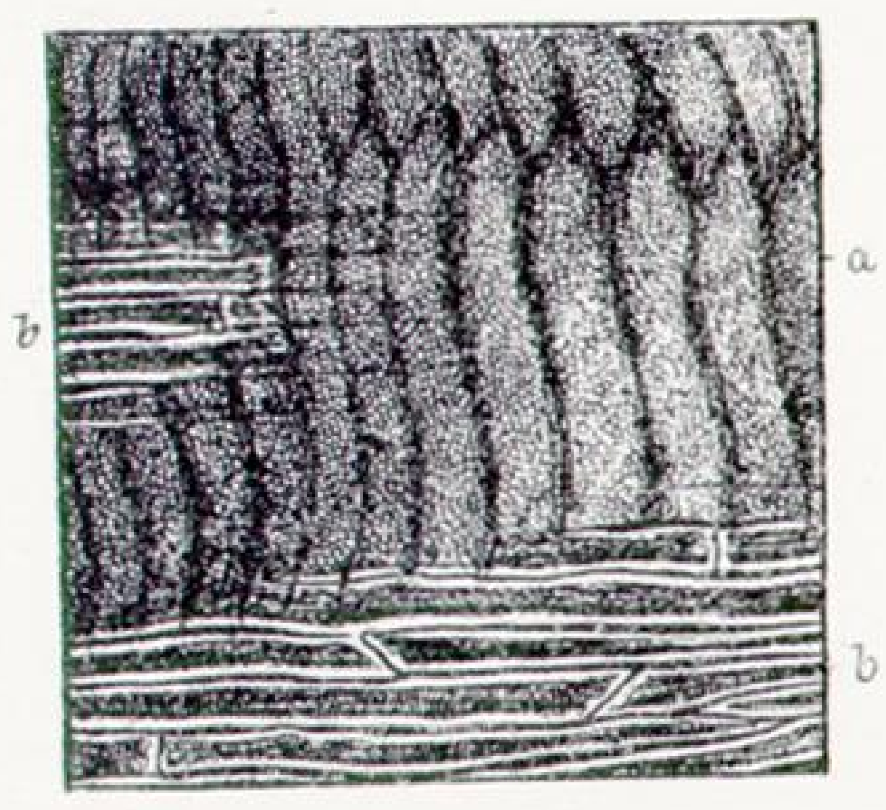

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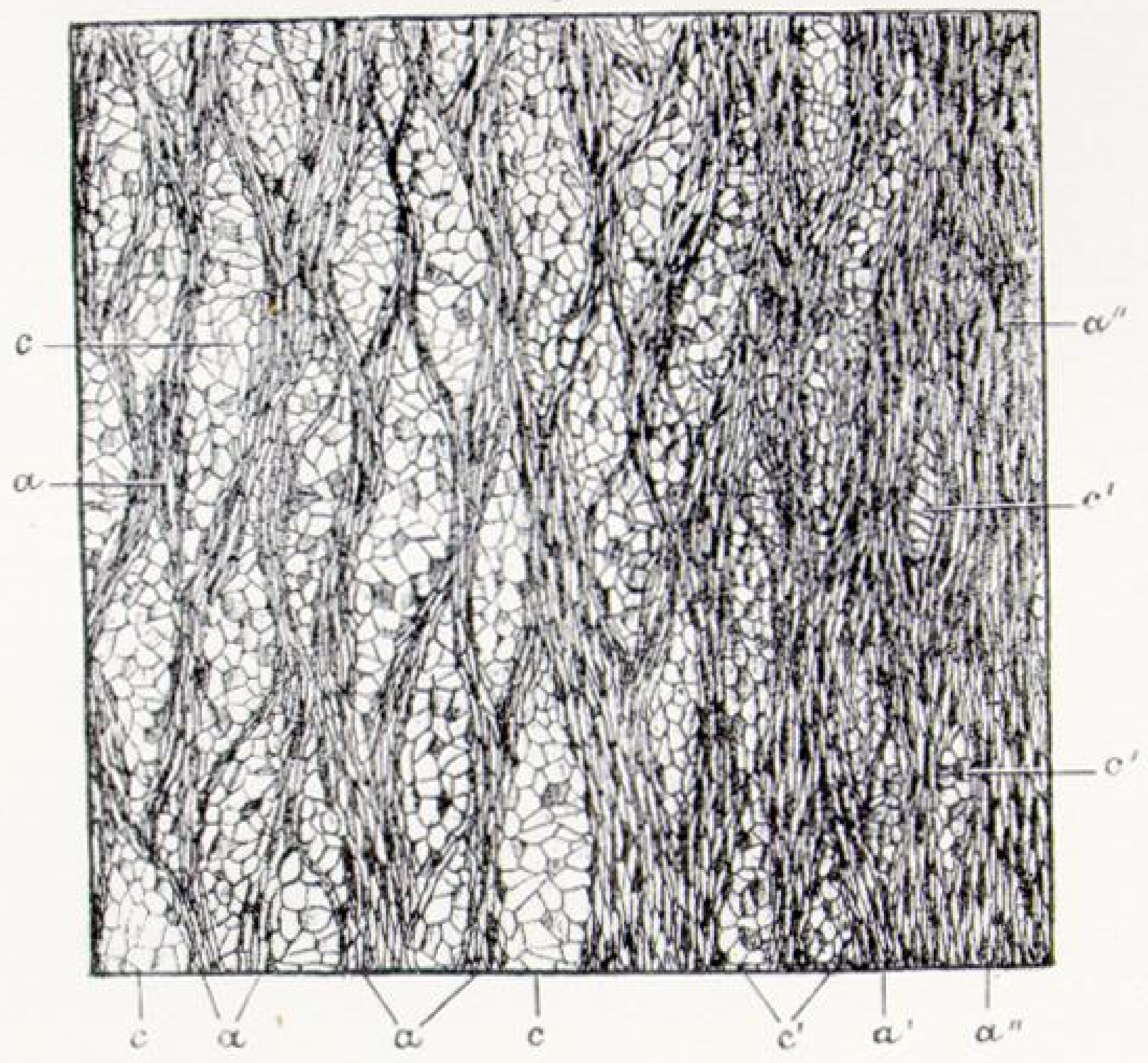

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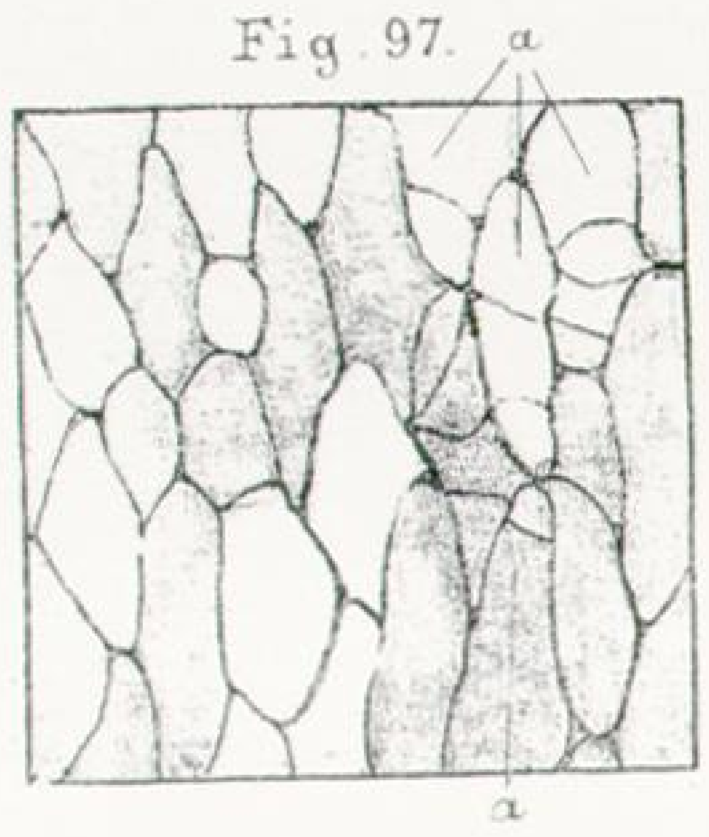

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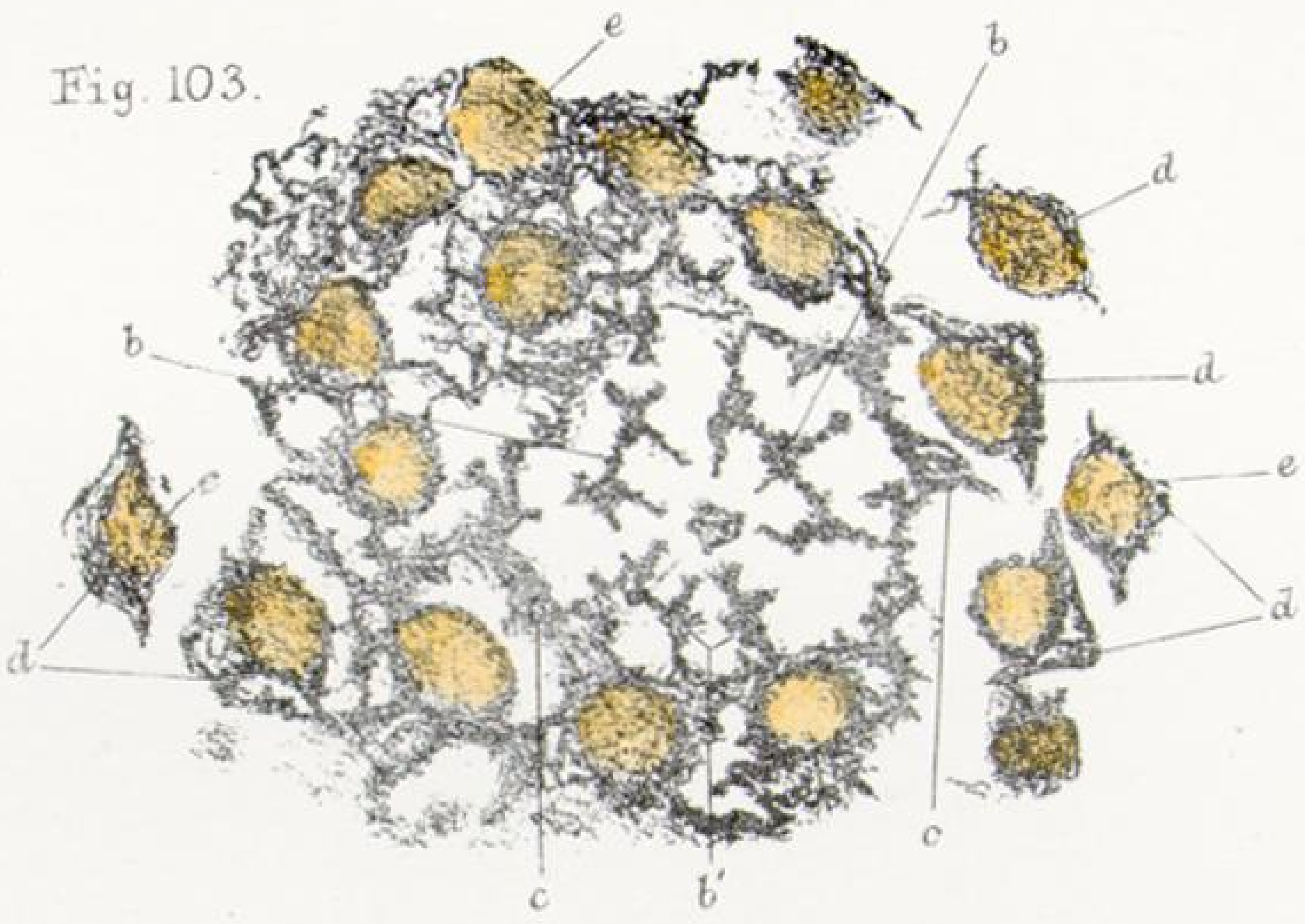

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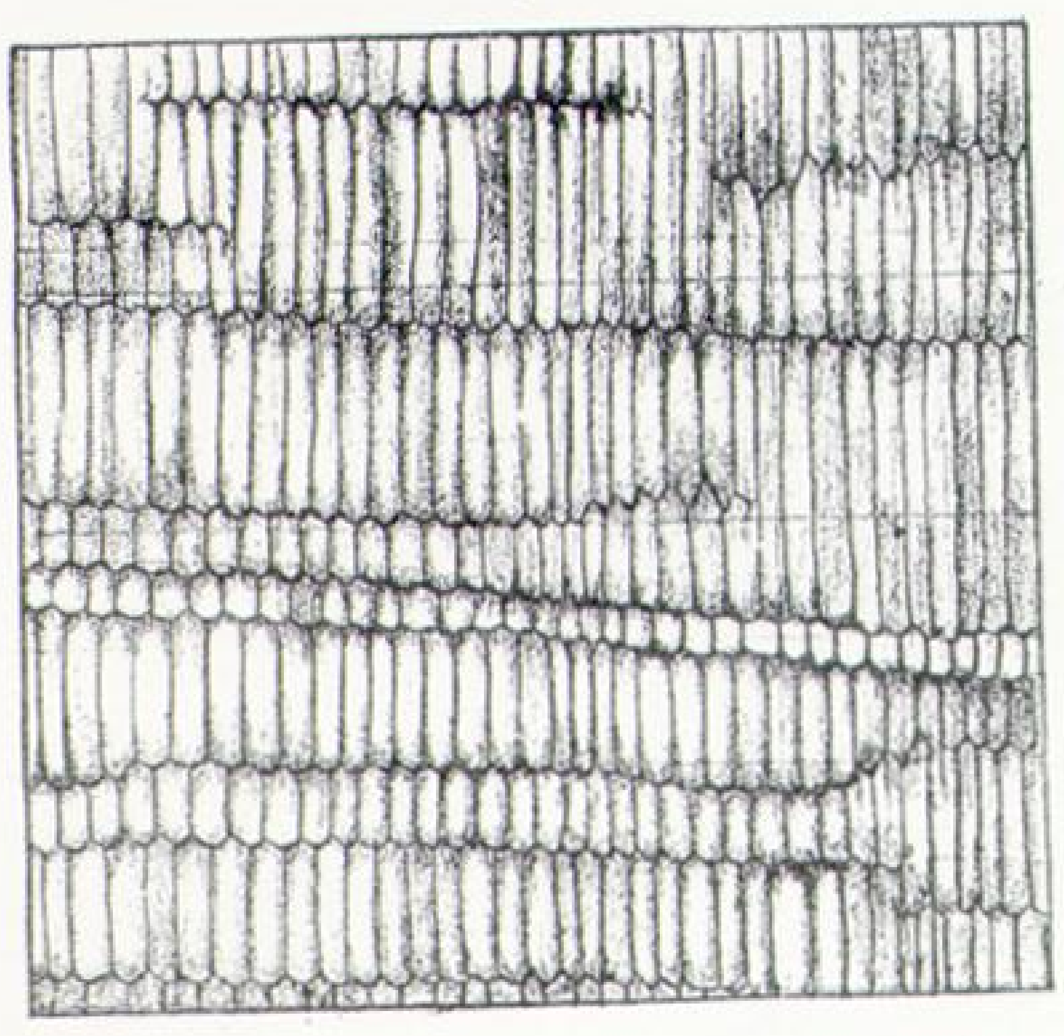

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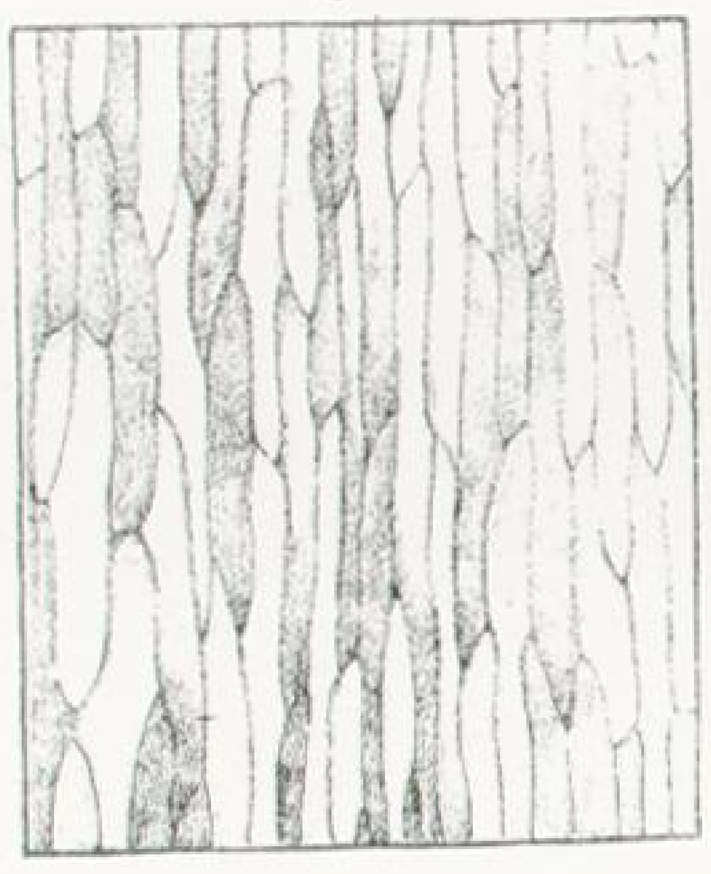
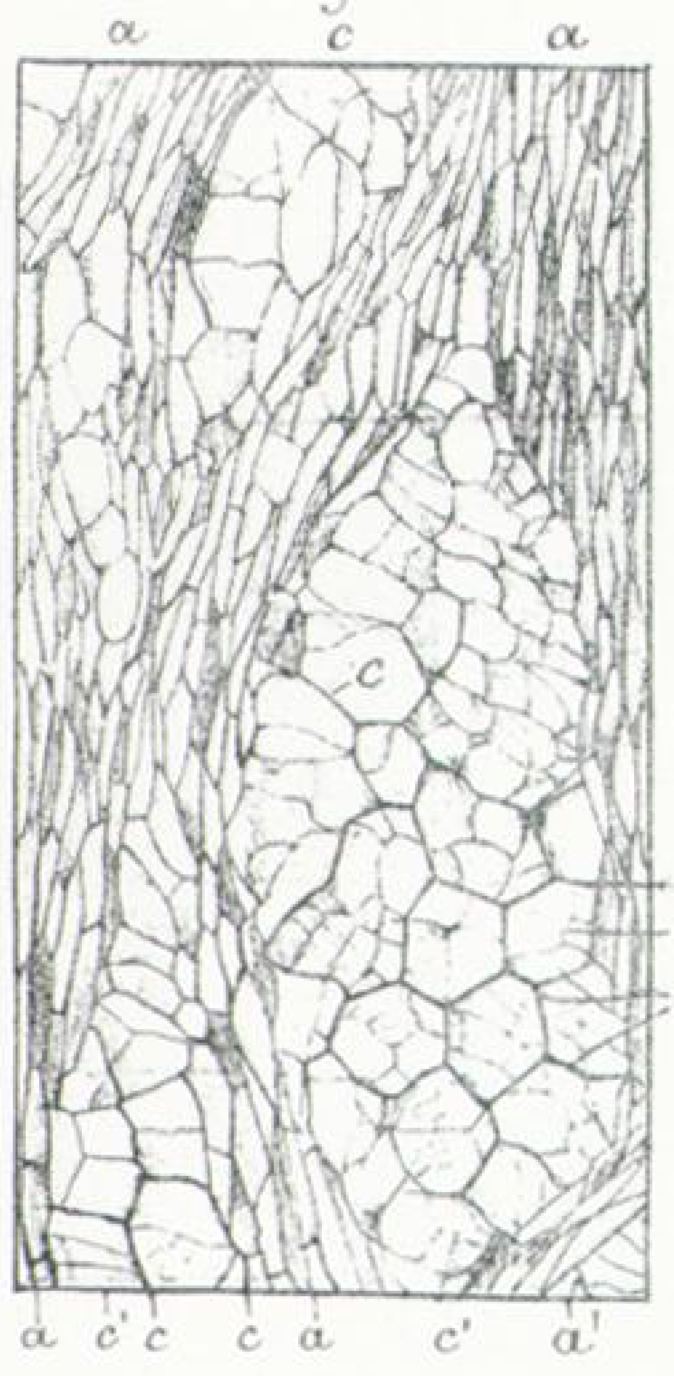


Fig. 101.



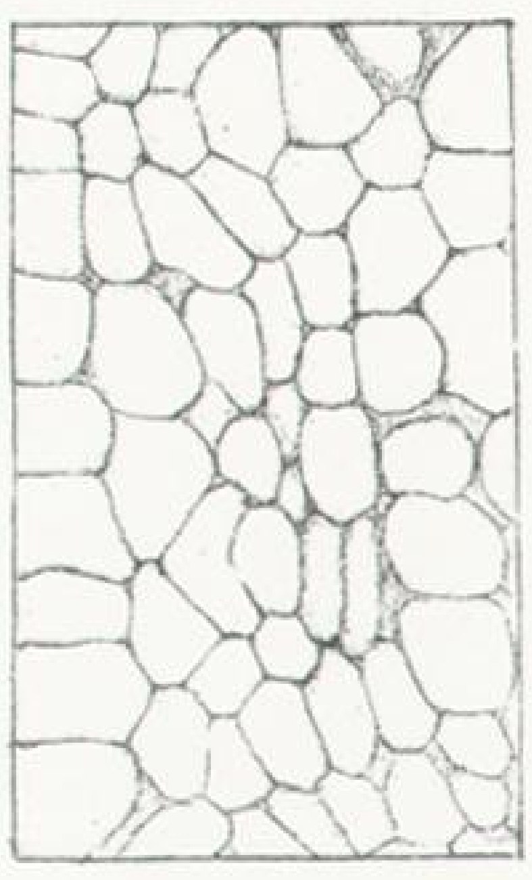


Fig. 96.

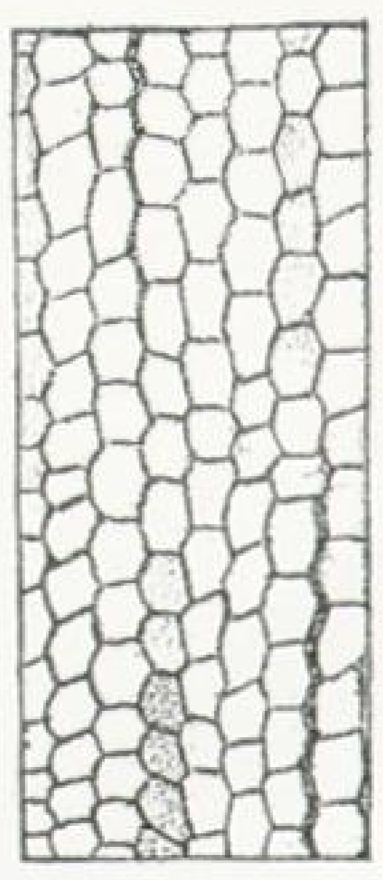


Fig. 98.

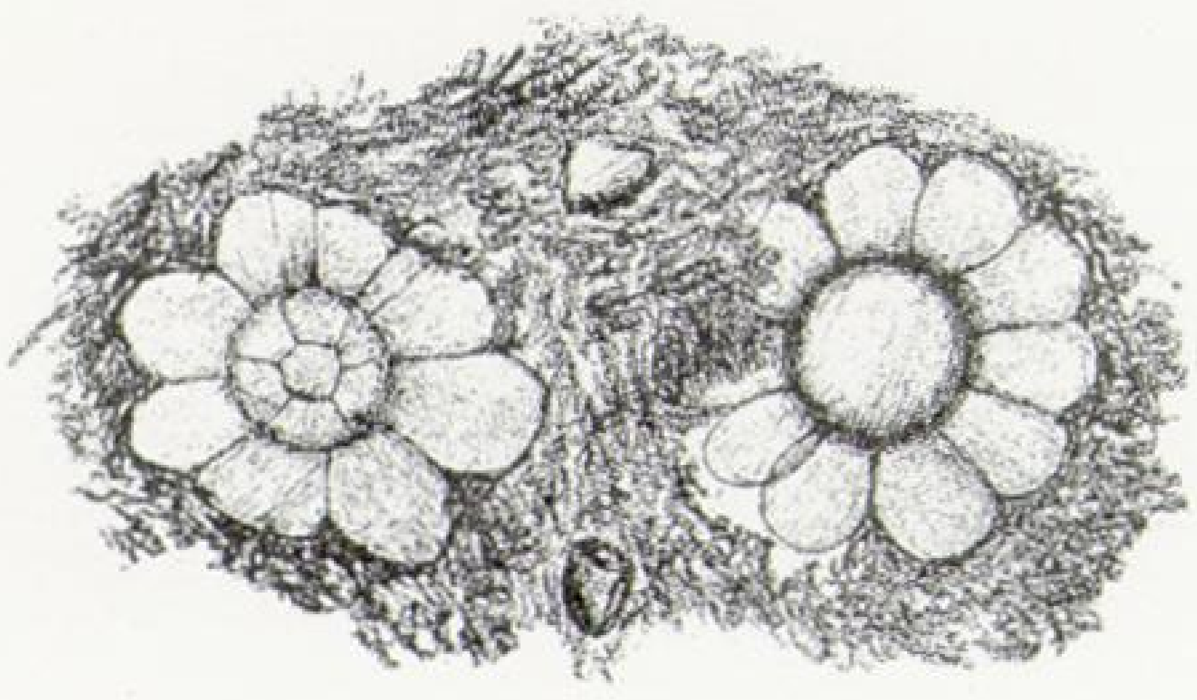


Fig. 102.

Lyginodendron (?) anomalum.

Fig. 90. Transverse section of the vascular zone of a stem from Arran. Enlarged 14 diameters.

Fig. 91. Part of fig. 90. Further enlarged to 50 diameters.

Fig. 92. Tangential section of the same stem. Enlarged 14 diameters.

Sigillarian or Lepidodendroid Bark.

Fig. 93. Transverse section of the outermost bark. Enlarged 8 diameters.

Fig. 94. Radial vertical section of fig. 93. Enlarged 8 diameters.

Fig. 95. Tangential vertical section of fig. 93, made in a line between the two stars. Enlarged 8 diameters.

Fig. 96. Transverse section of a fragment from the innermost portion of the same specimen. Enlarged 32 diameters.

Fig. 97. Tangential section of fig. 96. Enlarged 32 diameters.

Fig. 98. Transverse section of a portion of fig. 93, made in the line of *a*, *a*. Enlarged 32 diameters.

Fig. 99. Tangential section of fig. 98. Enlarged 32 diameters.

Fig. 100. Radial vertical section of fig. 98. Enlarged 32 diameters.

Fig. 101. Small portion of fig. 95. Enlarged 16 diameters.

Oidospora anomala.

Fig. 102. Unknown bodies. Enlarged 360 diameters.

Volkmannia parvula.

Fig. 103. Transverse section. Enlarged 54 diameters.