ON NEMATOPHYTON AND ALLIED FORMS

FROM THE DEVONIAN OF GASPÉ,

BY

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WITH INTRODUCTORY NOTES BY

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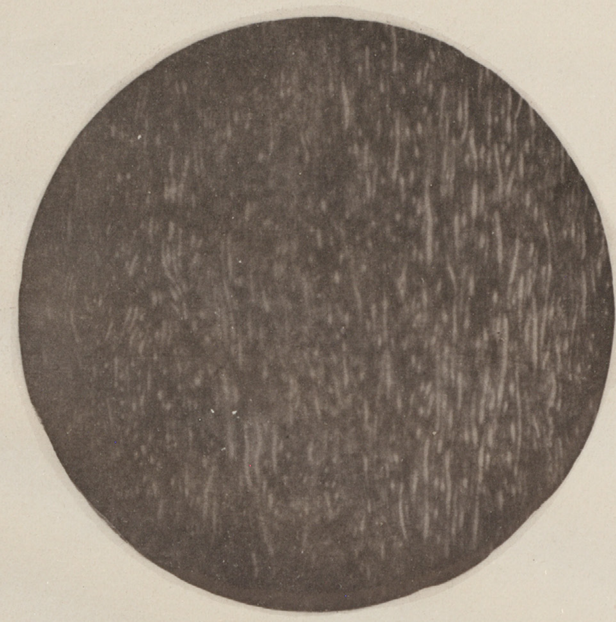

Fig. 1.

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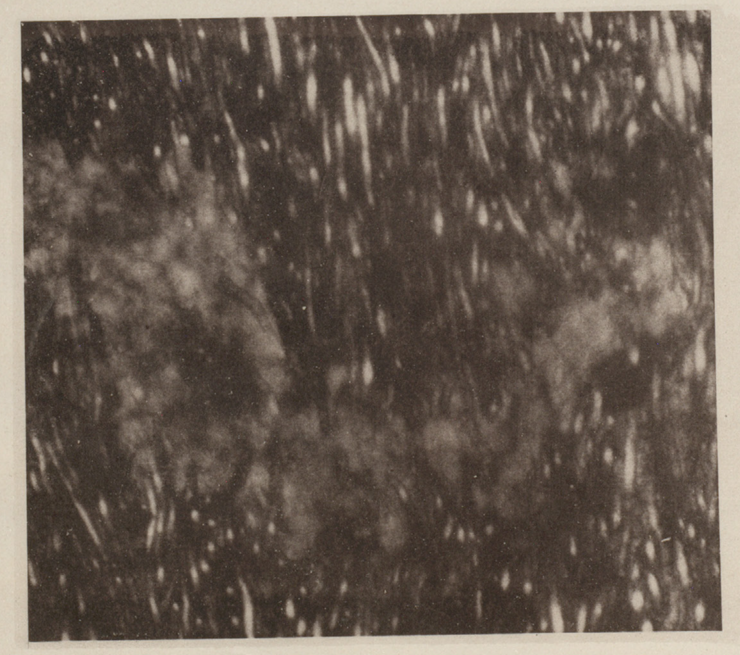

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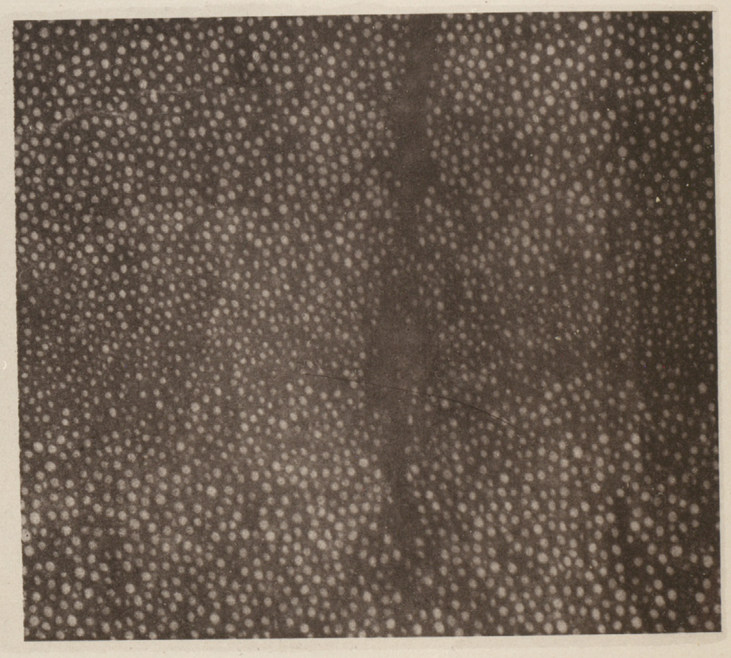

Fig. 3.

NEMATOPHYTON LOGANI, Dn.

ARTOTYPE, PATENTED; CANADA BANK NOTE CO., LIMITED, MONTREAL.

Fig. 5.

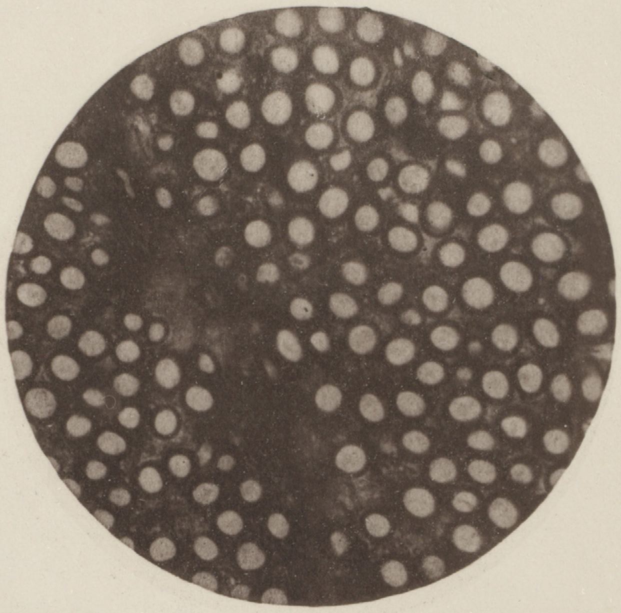

Fig. 6.

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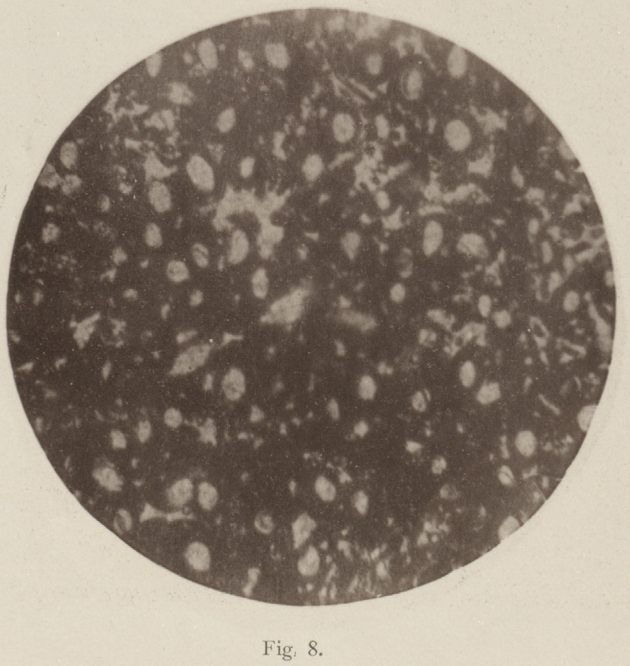

Fig. 8.

NEMATOPHYTON LAXUM, Pen.

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III.—*On Nematophyton and Allied Forms from the Devonian (Erian) of Gaspé and Bay des Chaleurs.* By D. P. PENHALLOW, B. SC. (*With Introductory Notes,* by SIR WILLIAM DAWSON, F.R.S.)

(Presented May 25, 1888.)

I.—INTRODUCTORY GEOLOGICAL NOTE. (*Sir W. Dawson.*)

1.—*Historical Sketch.*

My first introduction to the fossil plants since known as *Prototaxites* and *Nematophyton,* was in 1855. When in that year I came to Montreal, the late Sir W. E. Logan showed me, in one of the cases in the Museum of the Geological Survey, several large masses of black, silicified wood, which he had collected some years before in the Erian Sandstones of Gaspé, but which had not been studied microscopically. I was much interested in these plants, and in others since described by me as *Psilophyton,* more especially as they were the oldest fossil plants, other than Algæ, which I had seen ; being found, according to Logan, in the Lower Sandstones corresponding in age to the Lower Devonian of England. By Sir William's permission, I had slices of the best preserved specimens made by Weston, and found that the structures were in a very perfect state.

I had noticed that the trunk collected by Logan, which must have been a foot in diameter, had resisted the compression which had flattened the other plants in the same beds ; that the stems split into concentric layers when broken, like exogenous wood, and that they showed regularly arranged linear papillæ on the surface corresponding to the leaf-bundles of many fossil plants ; that they presented transverse swellings or nodes, and cavities or knots, indicating the breaking off of small branches ; that they possessed a coaly bark of remarkable thinness and density. All these appearances led me to infer, from past experience of fossil plants, that I had to deal with a very resisting and durable kind of wood. I was, therefore, not a little surprised when I found the structure to consist of loose, cylindrical tubes, running lengthwise in a very tortuous manner, and traversed by radiating horizontal spaces which I could only compare with the narrow and imperfect medullary rays seen in some Sigillariæ, and in the less perfectly organized types of Cycadaceous and coniferous trees. These spaces, however, showed no structure except loose tubes, which seemed to have fallen into them, but have been ascertained by Prof. Penhallow to have a structural signifieance. The rings of growth I found to consist of alternate bands of larger and smaller tubes, but the difference of these seemed insufficient to account for the very decided concentric cleavage and weathering of the stems, which was more marked than it usually is in Palæozoic Conifers.

The mode of occurrence and state of preservation of the specimens seemed to make it certain that they had belonged to land plants ; but my previous experience did not supply me with any similar structures. After carefully examining a number of slices with such microscopes as were then available, I concluded that these strange plants were altogether dissimilar from the Lepidodendra, Sigillariæ and similar trees of the Carboniferous, and the only plants which seemed to me at all similar were those "prototypal gymnosperms" which Unger had discovered in the Devonian of Thuringia, and had named *Aporoxylon*,[1] and which, with several other strange and mysterious plants of these old rocks, he had then recently described.

I was also struck with the resemblance of the tissue to that of certain Taxine woods when in a state of great disintegration. The wood of Taxus has remarkably long, cylindrical, and often somewhat tortuous fibres, and these are so loosely attached to each other that they appear almost round in cross-section, and they readily separate in decay. This property of the Yews gives them that remarkable toughness which commended itself to our ancestors for their bows, and the same peculiarity causes many of the fossil woods which have been referred to the genus *Taxites*, to present a very loose appearance, while when the outer walls of the cells are decayed, the inner lining seems quite cylindrical and crossed with minute fibres. This resemblance caused me to propose for the new plant the name *Prototaxites*, a name, perhaps, somewhat unfortunate, for though in my descriptions, I disclaimed any intention to suggest a close affinity to coniferous trees, botanists have persisted in inferring that I regarded this wood as coniferous and allied to Taxus.

A preliminary notice of the plant was communicated to the American Association at its meeting in Springfield, in 1856; but its more detailed description was prepared at a later date.

I have always endeavoured, in describing fossil plants, to visit the localities where they can be studied *in situ*, and to examine carefully their mode of occurrence and associations. For this reason, in 1858, I spent a week in Gaspé Bay, with the special object of collecting and studying this and other fossil plants. I had the the advantage of Sir W. E. Logan's notes on the various coast sections, on which he had indicated the several places where plants had been found. I revisited Gaspé with the same objects and spent a longer time there in the summer of 1869, assisted by Dr. G. M. Dawson and Prof. Kennedy. The results of these visits were, among other things, the discovery of the fructification and habit of growth of *Psilophyton*, of *Lepidodendron Gaspianum*, *Arthrostigma*, and other ancient vegetable forms of the Devonian rocks, and the finding of several trunks of Prototaxites at various points on the north shore of Gaspé Bay. At Little Gaspé I also found stumps with branching roots apparently rooted *in situ* in the shales and argillaceous sandstones of the locality. Our researches were also rewarded by finding fish remains of the genera *Cephalaspis* and *Machæracanthus*, and several other animal fossils which have been described elsewhere.

I also ascertained that these remarkable plants had probably grown in the clays and sands in which Psilophyton and other plants had been rooted, and consequently, that, though probably marsh plants, they were not marine. They must have grown on low flats, probably often inundated, though whether this was with salt or fresh water is indicated merely by the negative fact that no properly marine organisms occur in the containing beds.

It was farther ascertained that the coaly outer bark is a constant accompaniment, and,

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[1] Palæontolagie des Thuringer Waldes, by Richter and Unger.

therefore, represents a definite structure, that these trees attained a diameter exceeding two feet, had large and spreading roots and gave off lateral branches. Unfortunately, no structures referable to their foliage or fructification could be found. This was, however, not surprising, for it is the rule, in the case of fossil plants, that the beds holding trunks showing structure do not contain the more delicate organs.

It was farther found that *Psilophyton princeps*, *P. robustius*, *Arthrostigma gracile* and *Cordaites angustifolia* were constant associates of these plants. There were also in the sandstones, numerous fragments of fossil wood, showing structure similar to that of the trunks, and flattened branches of various sizes which might probably be referred to this species, though not showing structure or any definite external marking.

A little later, Dr. Robert Bell, when exploring on the rivers of Gaspé, found additional specimens, some of them with the structure very well preserved, and also specimens of a remarkable fossil resin, to which reference will be made in the sequel.

In subsequent visits to Gaspé and Bay des Chaleurs, other specimens were found, more especially a trunk no less than two feet five inches in diameter in the Bordeaux quarry opposite Campbellton, where it was associated with Psilophyton and quantities of fossil resin, and at Cape Bon Ami, where drift fragments were found in the marine Silurian shales associated with fragments of Psilophyton, and with the remarkable globular bodies named *Pachytheca*, to be noticed in the sequel. In 1870 I observed, in the Museum of the Geological Survey of England, fragments of woody matter in shales of the Ludlow formation holding *Pachytheca*, and on examining specimens kindly furnished by Prof. Etheridge, I found them similar to the Gaspé specimens. A still more interesting discovery is that of similar wood in the Denbighshire grits at the base of the Silurian, by Dr. Hicks.[1]

The wood-cuts (Figs. 1, 2, 3) show the mode of occurrence of some of the trunks, and in my Reports on the fossil plants of the Erian of Canada,[2] will be found many additional details as to mode of occurrence and state of preservation.

Fig. 1.—Trunk and branch of Nematophyton in Sandstone cliff, Gaspé.

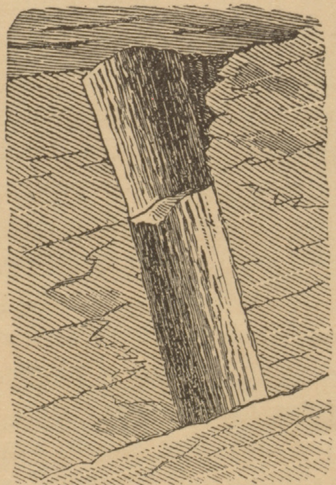

Fig. 2.—Erect trunk of Nematophyton one foot in diameter, Gaspé.

[1] Quarterly Journal Geol. Soc. of London, 1881.

[2] Geol. Survey of Canada, 1871 and 1882.

2.—*Geological Relations.*

North of Gaspé Bay, the Silurian limestones extend into the promontory of Cape Gaspé, with dips to the south-west. These beds, which attain a thickness of about 2,000 feet, hold numerous marine fossils, which in the upper part are those elsewhere characteristic of the Lower Helderberg series. Near Little Gaspé they are conformably overlaid by sandstones and shales, which in some places hold *Rensellaria ovoides* and other species found in the Oriskany of the west, and in which are also found the fucoids known as *Spirophyton.* These beds are the lowest in the great Erian or Devonian series of Gaspé Bay, which, according to Logan's measurements, is more than 7,000 feet in thickness. Arranged in a synclinal form, they occupy both sides of the bay.

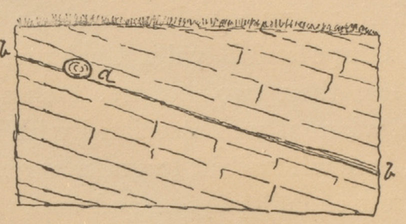

Fig. 3.—Section showing position of a prostrate trunk of Nematophyton, (*a*) on an underclay, (*b*) filled with Psilophyton—Gaspé.

A few fossil plants, mostly fucoids, occur in the Silurian limestones, but in one bed, not far above the base of the series, are fragments of rhizomata of *Psilophyton* in some of which the scalariform tissue of the axis is well preserved. In the overlying sandstones, fragments of plants are abundant, and in the lowest beds in Little Gaspé Cove, I observed two great stumps of Nematophyton with their roots spreading in the sandstone, while in the vicinity of this place there are underclays filled with rhizomata of Psilophyton, and extensive fields of these plants *in situ.* The following extracts from my notes of 1869 farther illustrate the structure of the Gaspé sandstones :—

"The Gaspé sandstones, as their name imports, are predominantly arenaceous, and often coarsely so, the sandstones being frequently composed of large grains and studded with quartz pebbles. Gray and buff are prevalent colours, but red beds also occur, more especially in the upper portion. There are also interstratified shaly beds, sometimes occurring in groups of considerable thickness, and associated with fine-grained and laminated argillaceous sandstone, the whole having in many places the lithological aspect of the coal measures. At one place, near the middle of the series, there is a bed of coal from one inch to three inches in thickness, associated with highly bituminous shales abounding in remains of plants, and also containing fragments of crustaceans and fishes (*Pterygotus, Ctenacanthus ?* etc). The beds connected with this coal are grey sandstones and grey and dark shales, much resembling those of the ordinary coal formation. The coal is shining and laminated, and both its roof and floor consist of laminated bituminous shale with fragments of Psilophyton. It has no true under-clay, and has been, I believe, a peaty mass of rhizomes of Psilophyton. It occurs near Tar Point, on the south side of Gaspé Bay, a place so named from the occurrence of a thick dyke of trap holding petroleum in its cavities. The coal is of considerable horizontal extent, as in its line of strike a similar bed has been discovered on the Douglas River, about four miles distant. It has not been recognised on the north side of the Bay, though we find there beds, probably on very nearly the same horizon, holding Psilophyton *in situ*.

"As an illustration of one of the groups of shaly beds, and of the occurrence of roots of Psilophyton, I may give the following section, seen near 'Watering Brook,' on the north shore of the Bay. The order is descending:—

	Ft.	In.
1. Grey sandstones and reddish pebbly sandstone of great thickness		
2. Bright red shale	8	0
3. Grey shales with stems of *Psilophyton*, very abundant but badly preserved	0	5
4. Grey incoherent clay, slicken-sided, and with many Rhizomes and roots of *Psilophyton*	0	3
5. Hard grey clay or shale with fragments and roots of *Psilophyton*	4	0
6. Red shale	8	0
7. Grey and reddish crumbling sandstone		

"Groups of beds, similar to the above, but frequently much more rich in fossils, occur in many parts of the section, and evidently include fossil soils of the nature of underclays, on which little else appears to have grown than a dense herbage of Psilophyton, along with plants of the genus *Arthrostigma*.

"In addition to these shaly groups, there are numerous examples of beds of shale of small thickness, included in coarse sandstones, and these beds often occur in detached fragments, as if the remnants of more continuous layers partially removed by currents of water. It is deserving of notice that nearly all these patches of shale are interlaced with roots or stems of Psilophyton, which sometimes project beyond their limits into the sandstone, as if the vegetable fibres had preserved the clay from removal. In short, these lines of patches of shale seem to be remnants of soils on which Psilophyton has flourished abundantly, and which have been partially swept away by the currents which deposited the sand. Some of the smaller patches may even be fragments of tough swamp soils interwoven with roots, drifted by the agency of the waves or possibly by ice; such masses are often moved in this way on the borders of modern swamps on the sea coast.

"In the sandstones themselves there are great quantities of drifted plants, principally fragments of Psilophyton, which are sometimes matted together, as if they had drifted in peaty sods, in other cases scattered loosely over the surfaces, and often in very small fragments. The sandstones also contain large drifted trunks and stumps of Prototaxites.

"In the coarser sandstones there are numerous bony spines of large fishes (*Machæracanthus*), and in some of the finer beds, spines and bony plates of smaller fishes, apparently of the genera *Coccosteous*, *Ctenacanthus* and *Leptacanthus*. In one of these beds my assistant, Mr. Kennedy, was so fortunate as to find a nearly perfect specimen of *Cephalaspis*, the first found in America, and a new species.[1]

"Some of the finer beds also hold shells of Lingula, and lamellibranchiate shells of the genus *Modiomorpha* of Hall. It is a curious point of coincidence of the Gaspé sandstones with the old red sandstone of Scotland, that there are, in some of the dark shales containing these shells and also fragments of plants, clusters of rounded bodies of the nature of the *Parka decipiens* of Forfarshire, though of smaller size than the Scottish specimens. When best preserved, they appear as flattened globes with a depression in

[1] Described by Mr. E. Ray Lankester in the Geological Magazine (1870) as *Cephalaspis Dawsoni*.

the centre of each, and laid close together in one plane. They are most frequently attached to loose valves of bivalve shells. They must have been soft bodies covered with a tough smooth membrane, and were probably the ova of molluscs or crustaceans. Of the latter, fragments referable to *Dithyrocaris*, *Eurypterus*, *Pterygotus*, *Ceriatiocaris* and *Beyrichia* occur in these beds.

"Prof. Hall has kindly compared the molluscous remains with those of the Devonian of New York. He does not profess to give a conclusive judgment on them, but states that their aspect is that of the Hamilton group.

"The only remaining point connected with local geology to which I shall allude is the admirable and exceptional facilities afforded by the Gaspé coast both for ascertaining the true geological relations of the beds, and for studying the Devonian plants, as distinctly exposed on large surfaces of rock. On the coast of the River St. Lawrence, at Cape Rozier and its vicinity, the Lower Silurian rocks of the Quebec group are well exposed, and are overlaid unconformably by the massive Upper Silurian limestones of Cape Gaspé, which rise into cliffs 600 feet in height, and can be seen filled with their characteristic fossils on both sides of the cape. Resting upon these, and dipping at high angles toward Gaspé Bay, are the Devonian sandstones, which are exposed in rugged cliffs slightly oblique to their line of strike, along a coast-line of ten miles in length, to the head of the bay. On the opposite side of the bay they reappear; and, thrown into slight undulations by three anticlinal curves, occupy a line of coast fifteen miles in length. The perfect manner in which the plant-bearing beds are exposed in these fine natural sections may serve to account for the completeness with which the forms and habits of growth of the more abundant species have been disclosed and will be described in the following pages."

The upper part of the Bay des Chaleurs presents another trough of Erian rocks somewhat similar to that of Gaspé Bay, but much richer in remains of fossil fishes. The lower beds, consisting of agglomerate, sandstone and hard shale, are well seen near Campbellton and on the opposite side of the Restigouche River in the Bordeaux quarry, which shows thick beds of sandstone perhaps a little higher in the series: Near Campbellton, the shales abound in *Psilophyton*, while *Arthrostigma* and *Leptophleum* also occur. At Bordeaux quarry there are numerous specimens of *Psilophyton* and *Rhodea*, and also surfaces covered with quantities of the resinous bark to be mentioned hereafter. The largest trunk of *Nematophyton* yet found in the Bay des Chaleurs, two feet five inches in diameter, occurs in this quarry (Fig. 4.), and also stumps with gnarled roots. That these beds, near and opposite to Campbellton, are Lower Erian, is proved not only by their stratification and fossil plants, but by the fossil fishes of the genera *Cephalaspis*, *Coccosteus*, etc., discovered in them and described by Mr. Whiteaves.

Farther to the east, in Scaumenac Bay, opposite to Dalhousie, the Upper Erian beds, consisting of grey and red sandstones and shales appear, and are overlain by the red conglomerates of the Lower Carboniferous. These beds hold fishes of the genus *Pterichthys*, and their characteristic plants are ferns of the genus *Archæopteris* which are not found in the lower series. Nematophyton is not known to occur in these upper beds.

The following table shows the general relations of the Gaspé and Bay des Chaleurs beds to those elsewhere :—

Subdivisons.	New York and Western Canada.	Gaspé.	Bay des Chaleurs.	Southern New Brunswick.
Upper Devonian or Erian.	Chemung Group.	Upper Sandstones, Long Cove, &c.	Scaumenac Beds.	Mispec Group. Shale, Sandstone and Conglomerate.
Middle Devonian or Erian.	Hamilton Group.	Middle Sandstones. Bois Brulé, Cape, Oiseau, &c.	Not yet recognised.	Little R. Group (including Cordaite shales and Dadoxylon Sandstone).
Lower Devonian or Erian.	Corniferous and Oriskany Groups.	Lower Sandstones. Gaspé Basin, Little Gaspé, &c.	Campbellton and Bordeaux Quarry.	Lower Conglomerates, &c.

So far as yet known, the trunks of Nematophyton are confined to the lower members.

3.—*Associated Organisms.*

The question naturally occurs with reference to a plant so widely distributed in space and time, whether any other organs than the stem and roots have been preserved.

Perhaps the most constantly associated body is that to which Hooker has given the name *Pachytheca*, from the Ludlow bone beds, holding also fragments of Nematophyton, and stems supposed to be those of land plants.[1] As described by Dr. Hooker, they are spherical bodies, varying in size from one line to one-quarter of an inch, and must have been hard and resisting, as they have suffered no compression or distortion. This is explained by the fact that their walls are fully twice as thick as the cavity they enclose, and are composed of radiating cells closely placed together. Hooker names the species *P. Sphærica*. Subsequently, Mr. Charles Brongniart described specimens of similar structure from the Carboniferous under the name *Ætheotesta*. He regarded them as possibly gymnospermous seeds.[2] Similar fossils have been described by me from the Devonian of Scotland, where they were collected by Rev. T. Brown. Still later I found these bodies not unncommon in the Silurian beds holding fragments of Nematophyton at Cape Bon Ami, near Dalhousie, and at the Bordeaux quarry, while Hicks has found them in the Corwen beds holding Nematophyton. It is farther to be observed that the radiating tubes resemble those of Nematophyton, not merely in their form, but in their evidently exceptional density and durability. The minute rounded bodies observed by Etheridge in the cells of the Corwen specimens, I take to be accidental and concretionary.[3]

This frequent association and similarity of structure leave no doubt in my mind that these bodies were connected with Nematophyton, and probably its fruit, and that the density and durability of the envelope or testa of these fruits was, as usually holds in similar cases, intended to protect the nucleus of the seed, and possibly to adapt it to floatage to a distance on water. Unfortunately, only the thick wall of these reproductive

[1] Journal Geol. Society, vol. ix, p. 12.
[2] Ann. des Sciences Naturelles, vol. xx.
[3] Journal Geol. Society, Aug., 1881.

bodies has been preserved, and so far as I am aware, the interior structures have perished. I have elsewhere noticed the microscopic appearance of these bodies, both in the Corwen specimens and those from Cape Bon Ami.[1]

Of the other plants found with Nematophyton, there are none that can with any certainty be connected with it. In the following notes, Prof. Penhallow has described some other stems or branches showing structure, but these were probably specifically or generically distinct. Psilophyton, its most common associate, was a low-growing plant, with cord-like rhizomata and an entirely different structure, having an axis of scalariform vessels with cellular bark. The same remark applies to Arthrostigma. The fucoids known as *Spirophyton* were low-growing plants of delicate, perishable texture. In the Gaspé sandstones and at Bordeaux quarry there are flattened, coaly, branching bodies, which may possibly have belonged to Nematophyton, and if I were disposed to conjecture as to possible foliage, I would refer to the long linear leaves without apparent nerves, which I have named *Cordaites angustifolia*, and which seem to have been attached in a spiral manner to slender stems or branches. No actual evidence, however, of the structures of Nematophyton in connection with these leaves has been observed.

Another singular associate of Nematophyton would seem to indicate that it was a resinous plant. In the sandstones of Gaspé basin there occur laminæ of a resinous substance resembling amber, associated with Carbonaceous films, and with fragments of Nematophyton. Specimens collected by the officers of the Geological Survey have been analyzed by Dr. Sterry Hunt,[2] and are regarded by him as a fossil resin, and the manner in which it occurs in thin sheets, and these attached to plates of coaly matter, indicates that it has been a secretion in the bark of some tree. The same material occurs in the same manner in the Bordeaux quarry in the flaggy sandstones holding Nematophyton. In these sandstones, the resinous matter is in thin shining structureless flakes, often attached to flakes of coaly matter, and evidently represents exudations of resin in or over vegetable surfaces. Now, as no other arboreal plant than Nematophyton is known in these beds, and as fragments of its structure are associated with the resin, the inference would be that the resinous matter was produced by it. If it was a resinous plant, this would also serve to account for the remarkable preservation of the fibrous structure of the mass of the stem, otherwise so inexplicable in a plant apparently of so lax structure. It is true that the resinous matter has not yet been actually found in connection with stems of Nematophyton, unless it is represented by a slight varnish of asphaltic matter, sometimes seen in what seem to be fissures of the stem, or by certain yellow microscopic bodies which appear in some slices of the roots, so that this reference must be for the present conjectural.

It may be said that resinous Coniferous trees, as yet unknown, may have existed ; but the genus *Dadoxylon*, the earliest of these trees, is not known to occur till the Middle Devonian,[3] though found at that, horizon, in various parts of America and of Europe, and there is no evidence that trees of this genus produced resinous matter, though in the vast number of trunks occurring in the Devonian and Carboniferous, some indication of this might have been expected, had it been present. On the other hand, in some of the beds

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[1] Fossil Plants of Erian. Geol. Survey, Canada, 1882.

[2] Logan's Geology of Canada, p. 791.

[3] Geology of Canada, *l. c.*

holding Nematophyton, so great quantities of fossil resin occur, that it has been proposed to inquire as to the possibility of its economic use.

4.—*General Relations.*

For the minute structure I may now refer to the careful examinations of Prof. Penhallow, who has had more complete material placed in his hands than has previously been submitted to any botanist, and whose extensive knowledge of vegetable anatomy well fits him for such an investigation. The only points on which I should be inclined to hesitate as to his deductions are those which relate to the bark and the probable existence of an internal pith or axis.

With respect to the first, though the coaly bark shows no distinct structure (the fibrous structure referred to by Prof. Penhallow belonging really to the outer part of the general tissue in contact with it), it is so constant in all the specimens I have studied and so clearly defined in limit and state of preservation, that I cannot doubt that it was as distinct as the similar coaly coating on other trees of the Erian and Carboniferous. It may also have lost much of its exterior material by abrasion. This is, I think, farther indicated by the strongly wrinkled and furrowed appearance which it presents in old stems.

With regard to internal axis or medulla, though this does not appear, yet the partial flattening and distortion of the stems shows that there was either an internal axis or an internal cavity. This is well seen in the indented outline of the great trunk in the Bordeaux quarry, as seen in Fig. 4. It is to be observed here that in Carboniferous trees of

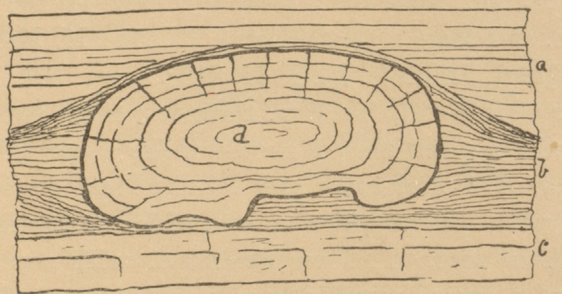

Fig. 4.—Prostrate and partially compressed trunk of Nematophyton 2½ feet in diameter—Bordeaux quarry, opposite Campbellton. (*a*) Flaggy Sandstone with resinous matter. (*b.*) Shale with Psilophyton. (*c.*) Sandstone. (*d.*) Silicified trunk with thin coaly bark.

the type of Sigillaria, it is not unusual to find a thick inner bark of long tortuous fibres, often constituting nearly the whole of the trunk, and which is much less perishable than the thin woody axis. I hold it, therefore, to be possible, that Nematophyton possessed either a cellular medulla or a woody axis or an internal cavity, which in all the specimens hitherto found has collapsed and disappeared.

Lastly, under this head, palæontology has made us familiar with many remarkable botanical anomalies, as the possession of true exogenous structure by acrogenous plants of the families of Lycopodaceæ, Equisetaceæ and Ferns, though this structure exists with the same types of scalariform and cellular tissue found in the modern acrogens. It would only be a farther extension of the same principle to find a pseudo-exogenous stem of still greater antiquity, constructed wholly or principally of long, tortuous fibres similar to those in some lichens and algæ, from which, however, I regard the tissues of Nematophyton as essentially distinct. It is farther to be observed that since Nematophyton extends downward from the Lower Devonian, and antedates any known Conifer, it belongs to a time as much older than the coal formation, as this is older than the Cretaceous, and so to a far earlier period of the earth's history. Thus it may represent a leading type of forest vegetation in the Silurian and early Devonian, and which disappeared before the introduction of the Dadoxylons and other trees of the Middle Devonian and later formations. I have also been disposed to regard it as possibly a late survivor of a type of vegetation which may have existed even in the Cambrian and Laurentian, and may have been connected with the accumulation of the great quantities of carbonaceous matter known in the latter, and with that of the vegetable debris abundant in some parts of the former, and which, though it has not yet afforded distinct structure, presents indications of longitudinal fibres akin to these of Nematophyton, and appears in similar angular fragments to those representing that type in the Silurian.

II.—Notes upon the Fossils. (*Prof. Penhallow.*)

1.—*Nematophyton Logani*, Dawson.

Prototaxites, Dn.

Nematophycus, Carr.; Jn'l Geolog. Soc. XV, 484; Aug., 1881, 482; May, 1882, 104; Geolog. Surv. of Can., 1863, 401; 1871, 16; 1882, II. 107; Can. Nat., (New Ser.), VII, 173; Ann. and Mag. of Nat. Hist. 5, IX, 59; M. Mic. Jn'l VIII, 160; X, 66, 208; XI. 83; Quart. Jn'l Mic. Sc. XIII. 313; Amer. Nat. V. 245, 185.

Early in the winter of 1886–'87, Sir Wm. Dawson placed several slides of Prototaxites in my hands, with the request that I should make a careful examination of them. The specimens consisted of several cross and longitudinal sections, all taken from the main stem of the plant, with the exception of one which was cut from what was at first thought to be a branch or root. This we shall deal with separately. Several of the sections—two in particular—were beautifully prepared, and admitted of very critical examination. From them were taken the photomicrographs, illustrating this paper. The others, thicker and more opaque, were used only for the determination of the more general structural features under a low power. The stem from which these sections were taken, and from which several others have more recently been cut, for the purpose both of verification and of more extended examination, is designated in the Museum collection as No. 5.

The literature of the subject, as cited above, is not very copious. It embraces a paper by Mr. Henry Hicks on the discovery of a plant in the Denbighshire Grits of Wales, which Mr. Carruthers identified as the *Prototaxites*[1] of Sir Wm. Dawson. With this exception, the literature consists chiefly of a discussion between the founder of the genus and species, Sir Wm. Dawson, and Mr. Carruthers, to whom specimens were

[1] *Nematophycus Hicksii* of Etheridge, Quart. Jn'l Geol. Soc., Aug. 1881, 494.

subsequently submitted for examination, relative to the proper structure and affinities of the plant. As it is the principal object of the present examination to throw such additional light as may be possible upon this controversy, it may be well briefly to pass in review the leading points of the discussion.

The original description of the plant is as follows[1] :—

"Woody and branching trunks, with concentric rings of growth and medullary rays ; cells of pleurenchyma not in regular lines, cylindrical, thick-walled, with a double series of spiral fibres ; discs or bordered pores few, circular and indistinct. The specimens are usually silicified, with the bark in a coaly state."

In the text following this description, Sir Wm. Dawson expresses a doubt as to the actual presence of discs, when he says that "all present cylindrical wood fibres, marked with irregular spiral lines, and indications, perhaps illusory, of small, round pores placed at unequal intervals. The woody fibres are of great length, but not closely in contact with each other, giving to the wood a lax appearance, like that in very young coniferous stems. The fibres are not placed in regular radiating series, but are divided into wedges by radiating bands representing the medullary rays, and there are distinct lines of growth in which the fibres are of smaller diameter than elsewhere."

The text further states that "with the exception of the lines of growth, I have failed to observe any change of structure in passing from the circumference to the centre. No pith has been observed, and the bark, when present, is thin and coaly. The roots have precisely the same structure with the stems, except that the fibres appear to be a little larger, and with the walls less thickened.

"In all the specimens there are evident indications of medullary rays, in radiating bands and lenticular spaces traversing the wood ; but the structure of the rays has perished, as one frequently observes in old and weathered trunks of modern trees. This would either indicate that the medullary rays were lax and perishable, or that all the specimens have been much decayed before fossilization.

"In one instance a large branch was observed to be given off, and on other trunks knots, representing the attachment of small lateral branches, like those of ordinary pines, were found. The most remarkable external marking consists in certain transverse swellings, which give to the trunk an irregularly articulated appearance. These swellings are connected with a gnarled appearance of the external layers of the wood, but the internal layers appear smooth, as if the structure supervened in an aged condition of the trunk."

Although the absence of proper vascular structure is also recognised, the plant is held to have a dense woody structure, and regular exogenous mode of growth.

In his account of subsequent examinations of this fossil, Mr. Carruthers makes the following statement :—

"Under a low power, a transverse section exhibits a somewhat loosely aggregated mass of circular openings of nearly uniform size, except that there are recurring tracts of smaller and more closely aggregated openings. These tracts have a concentric arrangement, and are the rings of growth of Dr. Dawson. On submitting the specimens to a higher power, we find that the circular openings have well-defined walls of considerable thickness, and that they are nearly uniform in size, except where the tracts of small dia-

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[1] Geol. Surv. Can., Fossil Plants, 1871, 16.

meters occur. It is obvious that all these openings represent the same kind of tissue—that is, as far as they are concerned, the structure is perfectly uniform and simple. We further observe that, while the majority are cut transversely, some are cut more or less obliquely, showing that the direction of all of them is not truly at right angles to the section. Thus they are separated from each other by spaces often as great as the width of the opening, and sometimes much greater. It cannot belong to a Phænogamous plant."[1]

After pointing out a want of resemblance to the vascular structures of Gymnosperms and Angiosperms, Mr. Carruthers combats the idea that medullary rays are present, and endeavors to show that the "double series of spiral fibres" in reality consists of an intercellular system of filaments, which traverse the structure in all directions. Finally, after directing attention to the peculiar structure and pseudo-exogenous growth of, as well as the great size sometimes attained by, certain Algæ, Mr. Carruthers definitely announces his views with reference to the probable affinity of Prototaxites, by assigning it to a new genus, *Nematophycus*.

It is unnecessary to review the discussion more in detail, and for a full account we must refer to the original articles cited; but with these salient points of the question before us, we are now prepared to see how far the present examination will serve to support the views announced. A *resumé* of what follows has already been given by Sir Wm. Dawson,[2] but we now desire to give the full results of our examinations up to the present time.

External Character.—Specimen No. 5, in the Peter Redpath Museum, exhibits the best preserved structure of all the specimens brought under my notice. It is black, and uniformly silicified throughout. The surface, which is marked by numerous rather fine, longitudinal ridges, shows the remains of a coaly layer, which appears to bear the relation of a cortical structure to the parts within. This layer is quite thin—hardly exceeding three mm.—and very friable, readily breaking up in all directions into irregular fragments. At about its central portion, the specimen shows a node-like swelling, which is traversed by a narrow furrow passing quite around the stem, thereby imparting an appearance closely resembling the node of a grass, and conveying the impression that it must represent the insertion of a broad-based, sheathing-leaf. Further examination, however, fails to show any remnants of vascular or other structure to support such a view.

Several very large specimens of more highly silicified trunks, wholly devoid of a coaly layer, show these swellings to occur at irregular intervals. It also appears that they rarely extend for more than a short distance in a transverse direction, and that they are not formed at a constant angle with the axis of growth. The appearance in such cases is well shown in a specimen figured by Sir Wm. Dawson in his original description of the fossil.[3]

None of the descriptions so far given recognise a pith, and in all of the specimens examined by us there is no evidence whatever to show that such a structure was ever present. The polished end of No. 5 does, nevertheless, exhibit certain lines (Plate I, fig. 2) which, from their radial direction and general disposition in the stem, bear a

[1] M. Mic. Jn'l, viii, 164.
[2] Geological History of Plants, 42.
[3] Geol. Surv. Can., Fossil Plants, 1871, plate ii, 19.

strong resemblance to true medullary rays. But a more critical examination discloses the fact that, in their want of continuity, and in certain other respects to be referred to more fully later, they possess peculiarities which are not consistent with true medullary rays. The transverse section, also, shows certain lines which give rise to false layers, undoubtedly referable to alteration under conditions of pressure. In addition to these, it is not difficult to also recognise certain fairly well defined layers, obviously due to differences of structure, and these layers, which are the "growth rings" of the original description, do bear a certain resemblance to the growth rings of exogens. Usually single (Plate I, fig. 3), they frequently appear double (Plate I, fig. 2). In No. 5 they are by no means concentric, but traverse the stem from side to side and find free terminations at the periphery, where they coincide with the longitudinal markings already referred to—the the more dense portions corresponding to the longitudinal ridges, while the less dense parts coincide with the corresponding furrows The peculiar disposition here noted is in all probability referable to changes under pressure, whereby both an alteration of form and a removal of the external layers were effected.

In the larger and more highly silicified specimens, where the form of the trunk is well preserved, the layers show a well-defined concentric arrangement, while the weathered extremity of one specimen shows a very distinct protrusion of the denser portions of the various layers, the less dense parts having weathered away precisely as occurs in true exogens.

Internal Structure.—A microscopical examination of transverse sections at once renders it obvious that the appearance of layers referred to, is dependent upon variations in density of structure. The inner face of each layer is composed of relatively large and thick-walled cells, having a diameter ranging from 13.6 μ to 34.6 μ—the average size approximating to the latter dimension. These cells are also separated completely from one another, often by intervals which considerably exceed the dimensions of the cells themselves (Plate II, fig. 6). The outer face of each layer is composed of relatively small cells, which range from 13.8 μ to 27.6 μ, their average diameter approaching the former figure. From this it is obvious that there is sufficient variation in structure to cause the definition of layers, but when, in addition to this, we look for any abrupt transition from the more dense to the less dense structure, such as commonly occurs in conifers and other trees of exogenous growth, we find it wholly wanting. There is, in fact, no abrupt termination of the denser layer on its outer face, but the small cells merge somewhat gradually with the larger cells, in both an internal and external direction (Plate I, fig. 3 and Plate I, fig. 2), so that were it not for the curvature of the layer itself, it would be very difficult to determine to which of the less dense adjacent portions the more dense tissue properly belongs. All transverse sections show, in more or less striking degree, one feature of the structure which at once arrests attention. While the plane of section may cut the majority of cells at right angles, it is found to cut others obliquely, so as to show a considerable portion of their length, thus proving very clearly, as Mr. Carruthers originally pointed out,[1] that all the cells do no not follow a parallel course, while it also

[1] M. Mic. Jn'l viii, 164; plate xxxi, c. We may remark here that the figures given by Mr. Carruthers, in his paper already cited, represent the various aspects of the structure in Prototaxites with great fidelity, as will be seen by comparison with the photomicrographs introduced into this paper.

indicates a distinct want of unity or of compactness in the structure as a whole. The want of parallelism thus shown is often seen in cross section in the strictly transverse direction taken by some of the cells. In longitudinal section this becomes much more obvious (Plate I, fig. 3), and in both sections is most pronounced in the immediate vicinity of the radial openings, into which the large, tubular cells penetrate at all angles[1] (Plate II, fig. 6).

A close examination of the transverse sections, also shows that the intercellular areas are more or less closely occupied by a system of much smaller, rather thin-walled filamentous cells, which are cut at various angles, sometimes exposing considerable length, at other times showing a transverse section. This structure becomes much more evident in longitudinal section, in which they are seen to cross the large cells in all directions. This feature, though not exhibited very clearly, is shown in one of the figures given by Mr. Carruthers[2], and is also conspicuous in Plate II, fig. 5, just to the right of the centre, on the upper margin of the figure, where the small cells traverse a large cell diagonally downward to the left.

Longitudinal sections show that the principal part of the structure is composed of tubular cells of indeterminate length. In none of the various sections examined have we yet been able to detect either a transverse septum or a tapering extremity; but that the cells are not organically united is very obvious, not only from the variable intervals which separate them, but also from their very sinuous course, in consequence of which they wind in and out among one another in a great variety of ways (Plate I, figs. 1 and 3). It is also found that the myceloid filaments referred to, as seen in cross section, are very numerous, and that they traverse the structure in all directions, forming a most conspicuous feature, the proper nature of which it would be difficult to mistake. These filaments have a diameter of 5.33 μ, and are the same as those found in the specimen to be described later. As these filaments cross the cells in all directions, they give to the wall of the latter a somewhat striated appearance, though a careful examination with good light cannot fail to discover their true nature. Nevertheless, we have observed that under certain conditions, they might be mistaken for striation of the cell wall. These filaments are the structures which gave rise to the original description of "a double series of spiral fibres," being figured as such by Sir Wm. Dawson.[3] They are more correctly shown in the figure by Mr. Carruthers,[4] which may be compared with photomicrograph in Plate II, fig. 5.

So far, all our examinations have failed to show any structure in the cell wall. It is also to be remarked that our specimens have so far presented no evidence whatever, to show that a proper intercellular substance or primary cell wall was present in the original structure, to unite the cells now visible. On the contrary, the entire aspect of the cells most forcibly suggests that they were either entirely free from the beginning, or that their union with one another could not have been established by anything more durable than a mucilaginous modification of the cellulose substance.

The ray-like openings in the tissue traverse the structure at right angles to the layers already noted. Sometimes they are continuous through two or more layers (Plate I, fig. 3), but more frequently their continuity is interrupted at short intervals, sometimes

[1] M. Mic. Jn'l viii, plate xxxi, *b*.

[2] M. Mic. Jn'l viii; Pl. xxxi, *c*.

[3] Geol. Soc. Can., Fossil Plants, plate ii, 26.

[4] M. Mic. Jn'l viii, 166, plate xxxii, *b*. *c*.

twice or thrice in the same layer. This appears in Plate I, fig. 2, where, to the left of the principal radial opening, a very short and detached area is seen to traverse only the smaller-celled tissue. A similar short opening is shown in longitudinal section in Plate I, fig. 4, the entire opening being brought within the limit of the figure. This shows that these open areas arise independently, and also that they pursue a very sinuous course with reference to the horizontal plane. Nor do they bear that constant relation to one another which might be looked for in true medullary rays. They frequently approach one another at a very considerable angle, and also show internal variations which it would be exceedingly difficult to account for in true rays upon any other ground than that of very advanced decay. Nor are these conditions of structure which can be satisfactorily explained on the ground of alteration through compression and other changes attendant upon the process of silicification.

In their internal structure, the "rays" show no evidence of cellular tissue. They are, on the other hand, irregularly elongated openings (Plate I, fig. 3), the central area of which is traversed in all directions by a felted mass of myceloid filaments of variable size. Very frequently, also, the large, tubular cells of the principal structure traverse these areas in all directions, and, in fact, it appears that it is in the immediate vicinity of these openings, into which they ultimately turn, that the principal cells take a direction obliquely or transversely to the axis of growth. In tangential section, these radial openings appear as channels of irregularly rounded form and size, without any regularity of disposition. The peculiarities of structure here indicated are clearly exhibited in Plate II, figs. 5 and 6, Plate I, fig. 3.

More recently, we have made a critical examination of the "node," as found in specimen No. 5, with the following results :—

The joint extends entirely across the stem in such a way that the removal of any part on either side exposes a flat face bearing a thin layer of a coaly, black substance. This leads us to infer one of two things, viz., that the joint represents a distinct transverse fracture, modified by longitudinal compression ; or that at this part of the stem there was originally a distinct septum, subsequently converted into a layer of coal, and its structure thus obliterated. Carefully prepared transverse and longitudinal sections passing through this particular part of the structure, were examined for any additional explanation they might afford. The former exhibited nothing which could be regarded as different from the structure in other parts of the stem. In the longitudinal section, the cells were, in some cases found to be more loosely disposed than elsewhere, and possibly exhibited a greater tendency to interlace, but in neither respect was the difference so marked as to enable us to regard it as peculiar to that particular part of the stem. So far as anything was indicated, it was that this region of the structure had sustained the full force of longitudinal compression, which thereby caused an external swelling of the trunk, with corresponding opening of the interior structure. This would harmonize with the appearance described by Sir Wm. Dawson. Moreover, along the entire face of the fracture, the cells were found to be all abruptly cut off, thus showing that instead of representing any peculiar structural feature, the joint is in reality a transverse fracture of the stem. The narrow opening thus formed eventually became filled with infiltrated material, and to a more limited extent with organic matter derived from the decay of the adjacent surfaces. In this we doubtless have a correct explanation of the amorphous coal film already referred to. Similar thin coaly films also fill the narrow clefts which traverse the stem at somewhat frequent intervals in a longitudinal direction, and which obviously originated in alteration under pressure.

An examination of the outer coaly layer from No. 5 shows that it has exactly the same structure as the interior silicified portions, whence we may infer that, on the one hand there could have been no differentiation of a proper cortical structure, and that the tissue of the stem was of the same kind throughout ; or else that with removal of the bark, were it originally present, the exposed surface layers of tissue were converted into coal.

Finally, we are prepared to consider one more structural peculiarity which has a most important bearing upon the true character of our plant, and its systematic position. We have already called attention to the fact that the large tubular cells take a horizontal or oblique direction, chiefly in the vicinity of the radial openings, into which they eventually run. The frequency with which this was found to occur, led us to the belief that there must be some special connection between the cells themselves and the open areas which they penetrated. For some time no adequate explanation could be reached, but after a careful search through all the sections then on hand, a single large cell entering the open area in a horizontal direction, was found to be distinctly branched. It had previously been noted that on entering these openings, the large cells usually became thinner-walled and more attenuated. The cell in question, however, was found to terminate in two distinct branches, the ultimate ramifications of which could not be determined on account of their having been cut away in making the section. In more recently prepared sections, we have found several such branching cells. In one case, five branches were found to arise from a cell at a section which was hardly longer than the diameter of the cell, and where there was a strong contraction in the latter. Other instances have also been noted. Not unfrequently the branching is indicated simply by a small round hole in the cell wall, where the branch projected towards the observer. In Plate II, fig. 5, on the extreme lower left-hand margin, there may be seen a cell with five distinct branches ; while to the right of the centre there is another cell with at least seven well-defined branches, some of which project towards the observer, and, therefore, appear as round openings only.

This branching, so far as observed, occurs only in the radial openings, though we see no reason why it may not occur elsewhere. From the relations which we have thus established, we have no hesitation in stating that the system of smaller, intercellular myceloid filaments are nothing more nor less than the ultimate ramifications of the larger cells, and that the radial openings are the special areas within which the branching is accomplished.

In order to gain a clearer idea as to whether or not the structure described could be considered normal, we examined a number of sections of fossil woods, in which the operation of decay was too evident to admit of question. We also submitted to examination an old tamarack (*Larix Americana*) water-log, which, having been in use for eighty years, was assumed to represent, to some extent at least, conditions of decay which would be liable to be represented in fossil woods. In neither case could we obtain any evidence to show that the fossil now under consideration had suffered special decay ; indeed, all the evidence pointed rather strongly in the opposite direction. It was at one time supposed by us that the intercellular filaments were fungoid mycelia incident to decay, but we have now proved these to be part of the normal structure. All the cells show a well-rounded form and sharp outline, with none of the breaking down which would at once appear in a decayed tissue. We are, therefore, justified in the conclusion that the structure of Prototaxites is wholly normal.

From the foregoing facts, we are justified in the following conclusions :—

1st. The plant is not vascular, and the appearance of rings is independent of the causes which determine the layers of growth in exogens.

That the plants were of very considerable size, must be admitted, since specimens have been found having a diameter of eighteen inches,[1] and this implies a very considerable height. It is also true that rings dependent upon structural variations are also present, but the relations which the more and less dense portions bear to one another, show that they are not true growth rings, and, at most, represent only a pseudo-exogenous growth. The possibility of such size and mode of growth, even among Algæ, has already been pointed out by Mr. Carruthers.[2] Moreover, we have proved, not only the absence of a proper vascular structure, but the absence of a pith and medullary rays as well. From this latter fact, it is clear that there could have been no external structure differing very materially from the internal ; wherefore we conclude that—

2nd. The plant was possessed of no true bark. The tissue was of the same kind throughout, and whatever cortical layer may have been present, was in all probability only a superficial modification of that composing the general structure.

3rd. An intimate relation exists between the large tubular cells and the myceloid filaments, the latter being a system of small branches from the former ; the branching being determined chiefly in special open areas which simulate medullary rays. The relation here shown was suspected by Mr. Carruthers, although, from the sections examined by him, he was unable to establish the fact.[3] The distinct branching of the larger cells, and their peculiar relation to the open radial areas, can, however, hardly be interpreted in any other way.

4th. The specimens examined exhibit no evidence of special decay, and the structure throughout is of a normal character.

We are now brought to a consideration of our final and most important conclusion, viz., the affinities of the plant. The absence of structural markings, of vascular and fundamental tissue, as well also of a cortex, together with the branching and non-septate character of the cells—all show conclusively that there can be no affinity with vascular plants, much less with the Gymnosperms, in consequence of which the name Prototaxites loses its value.

Mr. Etheridge has pointed out the occurrence, in *N. Hicksii*, of an occasional fine striation.[4] This marking we have also noted in the case of at least two cells of this species, but, from the condition of preservation, which all the material so far examined exhibits, together with the fact that no similar marking has been seen in either of the other two species brought to our notice, leads us to question if it represents actual structure in the cell wall itself. *N. Hicksii* is found only in the form of small fragments, which strongly suggest the action of the waves in breaking up the half-dried plants as they

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[1] Geol. Surv. Can., Fossil Plants, 1871, 17.

[2] M. Mic. Jn'l, viii, 170.

[3] M. Mic. Jn'l, viii, 169.

[4] Quart. Jn'l Geolog. Soc., Aug. 1881, 492; fig. 4.

were cast upon the beach. These fragments, instead of showing any well-connected structure, as in *N. Logani*, most generally break up into the individual cells, of which only the siliceous casts, to which fragments of the carbonized cell wall remain attached, appear.

The structure of Nematophyton is unique[1]; at least there is no modern plant with which it is strictly comparable. Nevertheless, the loose character of the entire structure; the interminable, interlacing cells; and, finally, their branching into a secondary series of smaller filaments, at once point with considerable force to its true relationship. That it is an alga, admits of no doubt; and so far as the structure alone will permit a final decision, its affinity with the Laminariaceæ, as first pointed out by Mr. Carruthers, who, therefore assigned it to the genus *Nematophycus*, appears to be highly probable.

Recently, Sir Wm. Dawson has modified his original views with regard to the nature of *Prototaxites*, and now assigns to it the name of *Nematophyton*,[2] a name which we have retained in the present paper.

Associated with *N. Logani*, Sir Wm. Dawson found a few small specimens of another fossil wood which he at first supposed might be a branch or root. An examination under the microscope, however, shows the structure to be, in some respects, quite distinct from *N. Logani*.

There are no concentric layers, nor are there any radial openings. The cellular elements are the same, but much more loosely disposed (Plate II, figs. 7, 8). The large tubular cells are non-septate, interminable, interlacing, and devoid of structural markings. In diameter they vary from 15 μ to 31 μ, and are, therefore, essentially the same as those in *N. Logani*, but, comparatively, they are very remote, and the large intercellular areas are filled in with a much more highly developed mass of fine, interlacing filaments, the diameter of which varies from 5.5 μ to 6.3 μ. While, therefore, the two agree in their main characteristics, there is a sufficiently marked difference to justify us in assigning the last to a distinct species, for which we would suggest the name *Nematophyton laxum*.

It only remains for us to summarise our results by including a description of the species so far as recognised.

Genus.—NEMATOPHYTON, *Dn.*

Prototaxites, Dn.

Nematophycus, Carr.

Plants of arborescent form from a branching, root-like base. Stem branching, often exceeding 1° in diameter. Structure composed of unjointed, interlacing, structureless and thick-walled cells, which branch into an intercellular system of small and closely-woven filaments.

1.—N. Logani, *Dn.*—Stem distinguished by its concentric layers, which simulate an exogenous structure; irregular and disjointed radial openings of variable length, and a thin cortical layer appearing in the form of coal.

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[1] The possibility of a connection between *Pachytheca* and *Nematophyton*, as pointed out by Sir Wm. Dawson, Mr. Carruthers and Mr. Etheridge, is of interest. These peculiar fruit-like bodies, together with certain laminated fossils found associated with *Nematophyton*, are now being examined, with a view to determining their possible relationship.

[2] Geol. Hist. of Plants, 21, &c.

Cells of the medulla, 13 – 35 μ in diameter, interwoven, loosely aggregated and turning into the radial spaces. Secondary structure composed of branching filaments 5 – 6 μ in diameter, which branch from the cells of the medulla and form a closely-woven intercellular plexus.

Lower Erian of Gaspé; Silurian (Upper Ludlow) of England; and Cape Bon Ami, New Brunswick (*Dawson*).

2.—N. LAXUM, *Pen.*—Concentric layers and radial openings, none. Cells of the medulla 15 – 31 μ in diameter, remote, and branching into secondary filaments 5.0 – 6.0 μ in diameter, which form a compact network, constituting at least half the structure, which is thus rendered very loose and spongy.

Lower Erian of Gaspé (*Dawson*).

3.—N. HICKSII, *Eth.*—This species occurs only in small fragments.

Cells of the medulla, 12 – 22 μ in diameter,[1] and somewhat compact. Secondary filaments, 1.0 – 1.5 μ in diameter, forming a rather less prominent plexus than in *N. Logani;* otherwise the same. Associated with this species there are frequently found clusters of spores measuring 1.58 μ in diameter.

Denbighshire Grit (Silurian) of Wales (*Hicks*).

2.—*Laminated Fossils, with* Nematophyton Logani.

In December, 1887, Sir William Dawson submitted to me, for examination, a somewhat peculiar fossil which he had found during the previous summer at Campbellton, New Brunswick. It was imbedded in a somewhat coarse, grey sandstone, and associated with numerous small fragments of vegetable matter. Externally, it presented the appearance of a piece of laminated brown coal, which it really was. Its dimensions were 2.95 cm. long by 1.35 cm. wide, and its thickness appears to be about the same as the width.

The laminæ, when separated, showed evident foldings. They were also found to lie at all angles of obliquity with one another, while they also proved to have been pressed into one another to such an extent that complete casts were frequent; showing that they must have been in a soft condition and subjected to considerable pressure while in that state. The entire appearance continually suggested a mass of irregularly compacted, half-rotten leaves.

Under a pocket lens, there appeared no external evidence of veins, but the surface exhibited minute foldings, and also everywhere presented the appearance of a fine cellular structure. Several of the laminæ were carefully separated from the mass and submitted to special treatment. Boiling with caustic potash for an hour or more produced no sensible change in the character or in the clearness of the structure. Nitric acid rendered the structure slightly clearer. On platinum foil the substance readily burned with a copious flame, leaving behind a coherent film of grey ash. When mounted in balsam and examined under the microscope, this failed to reveal any special structure, showing that the silicification had not extended far enough to preserve the details of structure.

[1] These measurements apply only to siliceous casts, and are, therefore, not strictly comparable with the preceding.

Numerous large cavities were, nevertheless, to be observed, indicating that the tissue of the plant was not continuous, but traversed in all directions by numerous intercellular spaces.

The laminæ are 0.25 mm. in thickness, and sometimes they show a tendency to split into two layers, as may readily be determined by a pocket lens. This would appear to indicate the presence, originally, of two outer and firmer membranes, enclosing a central layer of a less compact and resisting nature. Careful dissection showed that each one of the original laminæ can be wholly separated into two layers, each of which is similar to the other in its corresponding parts.

An examination of the internal structure proved it to have been badly preserved; nevertheless, areas were obtained where the tissue was sufficiently well preserved to enable us to reach fairly definite conclusions as to the nature of the remains.

The outer portions of the laminæ show a distinctly reticulated structure, approximating to an epidermal tissue, but no organs which could be referred to as stomata, were to be observed. In two instances out of several laminæ examined, a few openings in the structure were noted. These were narrowly elliptical, usually grouped within a narrow radius—in one case, five were found in two well-defined rows. Their average size, as determined from a measurement of six, was found to be 29.48 $\mu \times$ 86.36 μ Later measurements of other openings have given a greater size—52.6 $\mu \times$ 105.2 μ When the laminæ are complete, the openings are found to penetrate the structure for only a portion of its thickness, but when the former are split, the openings are then found to pass through, or nearly through, the separated parts. From this it would appear that they belong to the surface or cortical tissues, chiefly or wholly.

The interior structure of the laminæ consists of a mass of somewhat fine and numerously branching myceloid filaments, having a diameter of 1.59 μ — 2.12 μ with occasional filaments of a coarser nature, having a diameter of 4.7 μ There are also certain indications that much larger and rather thick-walled filaments may have been present, but of this we cannot be certain, as the structure is not sufficiently well defined. This entire system of filaments appears to find its outward termination in a reticulated structure, constituting the superficial tissue already described. Although this structure is, in most cases, destroyed, and, where preserved, difficult of determination, a very large number of examinations, under different conditions of illumination, amplification and treatment of the specimen, lead us to consider this as the true nature of the interior structure. Moreover, instead of forming a compact structure, the interlacing filaments enclose a large number of spaces or cavities, which are well defined and not to be mistaken. This, therefore, coincides with the appearance presented by the ash skeleton.

Both internally and externally, there is no trace of any vascular structure, and we are at least justified in the conclusion that the organism was purely cellular.

The structure thus described seems to indicate very strongly that our fossil must have been an Alga, and from a careful examination of the larger seaweeds found on the New England coast, we are led to consider it as allied to the Laminariæ, of which the genus *Saccorhisa* presents a structure with which it is fairly comparable, both with reference to its tissues and the openings or cryptostomata, which penetrate both surfaces of the frond. With reference to these latter structures, the only essential difference is one of size, the cryptostomata of *Saccorhisa* measuring 252.4 $\times$ 273.5 μ

Our examination indicates that the fossil consists of a mass of leaf-like organs, which, under the influence of partial decay, or through contained mucilage, became closely matted together. Subsequently, a portion was broken away from the mass, and after drifting an unknown distance, lodged and became fixed in the sand as found. This is the only view which appears to satisfactorily account for the peculiar form and character of the specimen.

That the laminæ are not the leaves of a vascular plant, is obvious from their structure, according to which we can only refer them to some Alga, of which they appear to have constituted the thallus. That this latter must have been narrow, or else composed of narrow divisions like the thallus of a Fucus, is suggested by the fact that all the laminæ showing entire margins do not exceed 1.6 cm. in width, while most of them are scarcely more than 0.5 cm. wide.

That the openings in the laminæ are cryptostomata seems to admit of little doubt, and this fact goes far to establish the true character of the fossil as algoid.

That these structures have an algoid character, and that they occur in the same beds with Nematophyton, suggests their possible connection with that plant as its fronds. This, however, must obviously remain a mere suggestion, since no further connection between the two can be traced at present.

Description of Figures.

Plate I.

Nematophyton Logani, Dn.

Fig. 1.—Longitudinal section, showing the peculiar interlacing of the cells. × 27.5.

Fig. 2.—Transverse section, showing a double "growth ring"; also a radial opening passing through the centre of the figure, with two smaller and isolated openings to the left. × 27.5.

Fig. 3.—Transverse section, showing a single "growth ring" crossing the figure transversely; and a radial opening. × 56.

Fig. 4.—Longitudinal section of the same, showing the general character of the structure; also, in radial section, a short radial opening, as represented on the left of Plate I, fig. 2, into which the cells of the medulla are seen to penetrate. × 56.

Plate II.

Nematophyton Logani, Dn.

Fig. 5.—Longitudinal radial section taken from the left central portion of the radial opening in Plate II, fig. 2, showing branching cells on the right and on the extreme left; also, two cells of the intercellular filaments crossing a large cell in the upper right-hand corner of the field. The clouded appearance of the large cells represents the disintegrated cellulose substance; the clear areas are portions of the vermicular cells cut away in making the section. × 154.

Fig. 6.—Transverse section of the same, showing the loose character of the structure and the thick-walled cells of medulla turning into a radical opening. × 154.

Nematophyton laxum, Pen.

Fig. 7.—Longitudinal section showing the very loose and spongy character of the structure. The dark longitudinal bands are the large tubular cells of the medulla; the finer, transverse lines are the intercellular filaments. The specimen much less perfectly preserved than in the preceding. × 154.

Fig. 8.—Transverse section of the same, showing the remote position of the cells of the medulla, the intercellular structure forming a somewhat dense mass. × 154.