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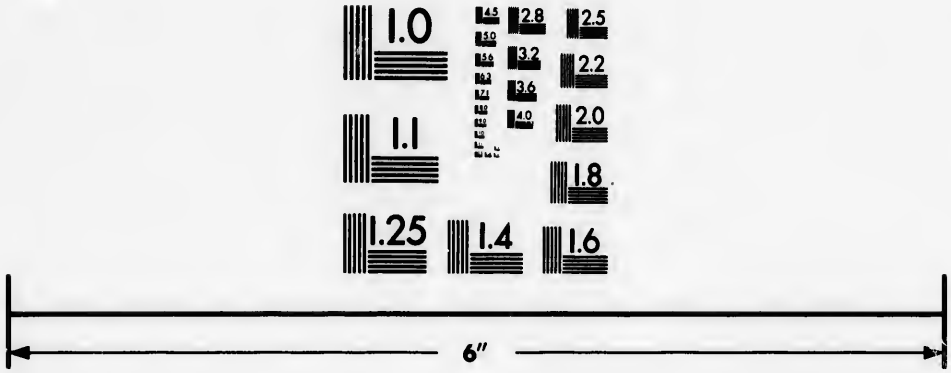

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III.—*On New Species of Fossil Sponges from the Siluro-Cambrian at Little Metis on the Lower St. Lawrence.* By SIR J. WILLIAM DAWSON, LL.D., F.R.S., &c. (*Including Notes on the Specimens,* by DR. G. J. HINDE, F.G.S.) [Plate III.]

(Presented May 7, 1889.)

The specimens described in the following paper show the existence of a rich fauna of siliceous sponges, more especially of the genus *Protospongia* of Salter, on the muddy sea bottoms of the Siluro-Cambrian period, and in that early portion of this period represented by the Quebec series of Logan, and probably by the Levis division of the group.[1] They are also remarkable as illustrating the structures and habit of these ancient forms and the manner of their preservation.

The beds at Little Metis have hitherto been very unproductive of fossils, but in the summer of 1887, Dr. B. J. Harrington, F.G.S., was so fortunate as to find a bed of black shale rich in remains of sponges, hitherto unknown in these rocks, and having made known the fact to the writer, we visited the place several times and made collections of these interesting fossils, which are now in the Peter Redpath Museum. Subsequently, in the summer of 1888, more extensive excavations were made in the reefs of shale exposed at low tide, and it was found that the deposits of fossil sponges are limited, so far as could then be observed, to two thin bands, each of them scarcely more than two inches in thickness, in the black shales near the head of Little Metis Bay. From these bands, by carefully tracing them along the coast and excavating where the exposures were sufficiently good, a large quantity of material was obtained. This was first carefully worked over by the writer and subsequently submitted to Dr. G. J. Hinde, F.G.S., of London, whose results are embodied in the descriptions of the species in the present paper. Later exploration showed that there are remains of sponges in other beds ranging through a vertical thickness of about forty feet of the shales; but not so abundantly as in the layers previously explored.

Little Metis Bay presents a good section of rocks of the Quebec group, including sandstones, slates and conglomerates similar to those which characterise this series of beds along the south shore of the St. Lawrence. The distribution of these beds is shown in the accompanying map,[2] from which it will be seen that the general dips are to the south-eastward, and that there appear to be four bands of sandstone and conglomerate separated from each other by intervening shales, often of dark colours and carbonaceous, but sometimes dolomitic, and in many places showing gray and red colours. Assuming the series from the Lighthouse Point to be an ascending one, the thickness of beds exposed at the head of the bay would be more than 3,000 feet; but it is not improbable that

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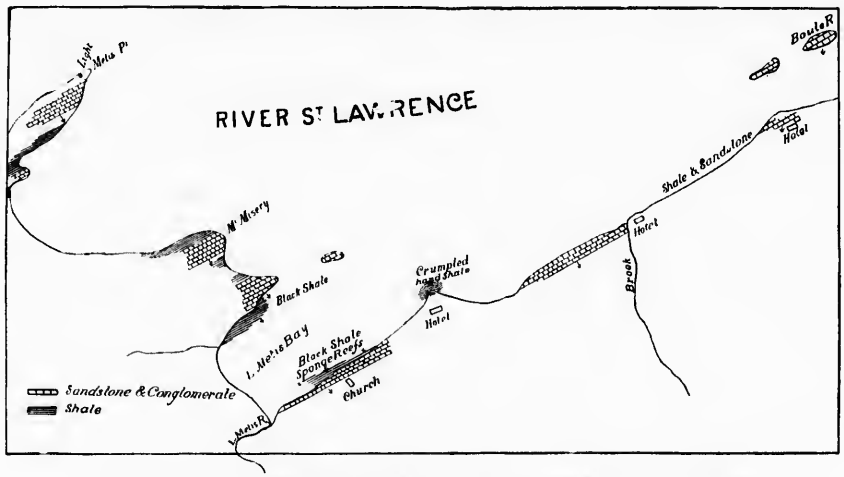
[1] Logan, Geology of Canada, 1863; Selwyn, Report Geol. Survey, 1877-78; Ells, *Ibid.*, 1880-82; Lapworth, Canadian Graptolites, Trans. Roy. Soc. Can., 1886.

[2] For the geographical part of the map on the following page I am indebted to Dr. Ells of the Geological Survey.

there may be repetitions by faults or folding. The sandstones and shales of Lighthouse Point contain *Retiolites ensiformis*[1] of Hall, many trails of worms, and worm castings of the type of *Arenicolites spiralis*. The sandstones of Mount Misery contain fragments of *Retiolites ensiformis*. The shales on the south side of the bay, presumably near the upper part of the series exposed, contain the sponges in question, a species of Linnarssonia not distinguishable externally from *Obolella pretiosa* of Billings, and the slender branching fucoid which I have described as *Buthotrephis pergracilis*.[2]



Sketch map of Little Metis Bay and vicinity, showing locality of Fossil Sponges.
(Scale about 2 inches to a mile.)

NOTE.—The series from the Church to Mt. Misery is probably descending and conformable; but the sandstones forming the cliff near McNider's Brook to the eastward, are not improbably those of Mt. Misery thrown to the southward by a fault, and not as would appear from the map a continuation of those near the Church, which probably pass inland of them.

In the conglomerates are limestone boulders, holding fragments of Trilobites of the genus *Solenopleura* and other fossils; but these seem to be of Lower Cambrian age, or considerably older than the beds in which they occur.

There can be no doubt, from the stratigraphical position of these beds, that they belong to the Quebec group of Sir W. E. Logan. This is, however, now known to include, on the Lower St. Lawrence, beds ranging from the Calciferous (Tremadoc) to the Trenton (Bala), and the beds are so much plicated that it is often difficult to unravel their complexities of arrangement. At Metis, the evidence of the pebbles in the conglomerates indicates that they are newer than the Lower Cambrian, and the few fossils found in the sandstones and shales would tend to place them at or near the base of the Levis division, or approximately on the horizon of the Chazy, equivalent to the English Arenig. Lapworth, in his paper on "Canadian Graptolites,"[3] suggests that the sandstones holding Retiolites may be older than this; but hitherto we have not found at Metis the charac-

[1] Identified by Lapworth.
[2] Notes on Specimens in the Peter Redpath Museum, 1888.
[3] Trans. Roy. Soc. Can., 1886.

teristic Graptolites of the older or Matane series, which occurs further east, and is probably of Calciferous or Tremadoc age.

The locality of the fossil sponges to be described, is the beach at the foot of the cliff in front of the Wesleyan church, on the south side of the bay, where a considerable thickness of black and gray shales is exposed, forming low ledges extending along the beach parallel with the direction of the coast. The dip is S. 10° W. (magn. var. 22° 33′ W.) at angles of 45° to 50°, and the beds containing the sponges are best seen opposite a huge boulder of conglomerate on the beach, and about 90 feet from the face of the cliff. The sponges were first discovered in a thin layer of tough black shale having hard gray and soft black beds associated with it. A second similar layer was afterwards found about nine feet outside the first and therefore underlying it, besides other beds holding fragmentary remains (see section below). Both these layers have Linnarssonia and *Buthotrephis pergracilis* associated with the sponge-remains.

The following is a general section of the beds in descending order :—

(1.) A thick bed of hard sandstone or quartzite and conglomerate, underlaid by coarse gray arenaceous shales, and forming the cliff immediately in front of the church. It shows in some of the beds radiating markings (*Astropolithon*).

(2.) Black and gray shales, the former thinly laminated and of fine texture, the latter harder and arenaceous, with some hard calcareous or dolomitic bands—thickness about 100 feet. The black shales of this division hold sponges and layers of sponge spicules, especially in the two bands above referred to, with fucoids (*Buthotrephis*) and valves of *Linnarssonia*. All of these fossils are usually in a pyritised state.

(3.) Flaggy sandstone and shale, gray and dark-colored, about twenty feet.

(4.) Hard gray sandstone with quartz veins, three to five feet.

(5.) Hard gray shales and calcareous and dolomitic bands, with some layers of sandstone—800 feet or more.

(6.) Apparently underlying these, and occupying a great extent of the shore, are black, gray and red shales and thick beds of gray sandstone, the latter appearing at Mount Misery and Lighthouse Point, and holding the Graptolites above referred to. These beds must be of great thickness in the aggregate, but they are possibly repeated in part by faults and contortions.

Along this coast the beds generally run approximately parallel to the shore, or slightly oblique to it, with south-easterly dip, but at intervals they are broken by transverse fractures throwing the beds, locally, into different lines of strike, and often accompanied by violent contortions of the strata. Beyond these they resume their usual course, so that the outcrops form a series of salient and reëntering angles along the coast. At the south side of Little Metis Bay there is a comparatively undisturbed portion, extending for more than half a mile along the coast, but there is one break, throwing the beds nearly at right angles to their former position, at the mouth of Little Metis River, in the head of the bay, and another to the eastward near Turriff's Hotel, where the beds, as seen on the beach, are much contorted. Beyond these breaks, beds similar to those holding the sponge-remains appear to the westward at Grand Metis Bay, and similar beds appear with like accompaniments near Bic. To the eastward they appear at several places on the coast, and have afforded graptolites of Levis and calciferous age.[1]

[1] Report of Peter Redpath Museum, no. ii; Lapworth, Canadian Graptolites.

The following is a more detailed section of part of the second division above, in descending order, measured on the surface of the outcrop :—

	INCH.
Black shale	8
Dolomitic band (weathering yellow)	3½
Gray and black shales	12
Dolomitic band	1
Black shale	6
Gray and black shales	15
Black shale	8
Gray and black shales	30
Black shale (sponges, &c.)	3
Black and gray shales, with remains of sponges in some layers	72
Dolomitic band	2
Black and gray shales	34
Dolomitic band	3
Black and gray shales	36
Black and gray shales (sponges, &c.)	
Black and gray shales, with thin, interrupted dolomitic layers as before, to base of the division.	

A third sponge-layer was found in the lower beds, about 30 feet vertically, or 50 feet measured on the shore, below the last dolomitic band. The sponges contained in the layers mentioned above, are apparently confined to a small thickness of the shale, but in this are quite abundant. They are perfectly flattened, and their spicules are replaced by pyrite; but in some cases they retain the outline of their form, and have their root spicules attached. The spicules were, no doubt, originally siliceous, but they have shared the chemical change experienced by other fossils in this bed, whereby they have lost their siliceous matter and have had pyrite deposited in its place. In some cases, also, the pyritised spicules have been frosted with minute crystals of the same substance, greatly enlarging their size and giving them a mossy appearance. This pyritisation of spicules, once probably siliceous, is not uncommon in Palæozoic rocks, and it arises from the soluble condition of the silica in sponges, and its association with organic matter, which, in some modern sponges, as in Hyalonema, enters into the composition of the spicule itself. These spicules, therefore, suffer the same change with the calcareous shells associated with them.

Many of the sponges in these beds were entire when entombed. Others are decayed and partially broken up, and there are some surfaces covered with confused patches of loose spicules arising from the disintegration of many specimens.

Some remarks are perhaps necessary here respecting the appearance of sponges in different states of preservation. Of course the original textures of sponges are different, and those which have consolidated spicules or firm external cortex, are those most likely to retain their original forms. Even the looser kinds of sponges, however, may under certain circumstances, preserve their rotundity of form. In this case they usually show external markings, but not so well internal structure, unless when sliced. On the other hand when completely flattened, which is usually the case in shaly beds, only an outline of the general shape remains, and sometimes not even this, while the forms and in part the arrangement of the spicules are usually apparent. Farther, the hollow and thin-walled species are more liable to be completely flattened, though in some cases, as in the Devonian Dictyospongiæ, they may retain their form. It was this property, and the membranous appearance of the outer coat, that for a long time sustained the belief that these last were plants rather than sponges.

In the case of the sponges procured in the shales at Little Metis, perfect flattening has occurred, and in many cases the spicules have been separated, and appear as mere

spicular patches or layers. In other instances, however, they remain approximately in their natural position, and even the general outline of the form can be observed.

The following additional remarks as to the state of preservation and characters of the specimens are from notes made by Dr. G. J. Hinde, F.G.S. :—

" The Metis specimens are specially interesting, since they throw much fresh light on the character of the earliest known forms of these organisms, and their discovery is the more opportune from the fact that our knowledge of the existing hexactinellid sponges—the group to which all, or nearly all, these fossils belong—has been vastly increased by the work of Prof F. E. Schulze, of Berlin, on the hexactinelled sponges dredged up by the Challenger Expedition, and thus we are now better enabled than hitherto to compare the fossil and the recent forms.

" In the present specimens, the amorphous or soluble silica, of which their spicular skeletons were originally composed, has entirely disappeared, and the spicules now consist of iron pyrites. This replacement by pyrites is of common occurrence, more particularly in a matrix of black shales; for example, the earliest known sponge, *Protospongia fenestrata*, Salter, from the Cambrian rocks of South Wales, is in the same mineral condition, and in a nearly similar matrix, as the specimens from the Quebec group and the Utica shale. When thus replaced, the general outline of the larger spicules is fairly distinct, but where the spicules are minute, and in close proximity to each other, their individual outlines are blurred by the tendency of the crystals of the replacing pyrites to amalgamate together so as to form a continuous film of the mineral in which the finer spicular structures are quite indistinguishable. This coalescence of the pyrites likewise makes it very difficult to determine whether the spicular elements of the sponge were organically soldered together into a siliceous mesh, or whether they were merely held in their natural positions by the soft animal structures, and owe their present union to subsequent fossilisation.

" Next to the chemical changes, we have to take into account those produced on the original structures of these sponges by what may be termed the mechanical influences of fossilisation. There can be no doubt that they were hollow sacci-form or vasi-form structures with very delicate walls of spicular tissue, supporting the soft animal membranes. They existed at the surface of the soft ooze of the sea-bottom, and their basal portions were probably embedded in it. They were furnished with elongated spicules whose extension into the mud served to anchor them in one spot. After the death of the animal, and the decay of the soft tissues, the delicate skeletal framework would be gradually buried in the accumulating sediments, until by their weight it became completely flattened. Under favorable circumstances, the outline of the sponge and the natural arrangement of the spicular skeleton would be preserved, and this is fortunately the case with the specimens of Cyathophycus from the Utica shale, and with some of the specimens of Protospongia from Metis. More frequently, however, probably owing to currents and other causes acting at the surface of the ooze, the skeletal framework is partially or wholly broken up, so that only small patches of the connected skeleton, or merely the dislocated and detached spicules irregularly scattered over the rock surface, remain for determination, and this is the present condition of the majority of the specimens from the Quebec group. For some reason, probably connected with the arenaceous character of the rock in which they occur, the nearly allied sponges belonging to the Devonian genus

Dictyophyton, Hall, usually retain their outer forms complete—that is, without being compressed—but most of these sponges exhibit only internal casts of their spicular skeleton, so that at present we know very little of their original structures.

"As already mentioned, nearly all these Quebec sponges belong to the suborder of the Hexactinellidæ, in which the fundamental type or elementary spicule of the skeleton consists of six equal rays, radiating from a common centre at right angles to each other, forming three equal axes. But this typical form is subject to great modifications through the unequal development or even suppression of one or more of the individual rays, so that spicules with five, four, three, or merely two rays only, are frequently present, and in the same species of sponge several modified forms of spicules may be found. Now, in the compressed condition in which the Quebec sponges occur, we can, as a rule, only perceive those rays of the spicules which lie in the exposed plane of the rock; these are generally the four transverse rays of the normal spicule, but the two rays forming the axis at right angles to the transverse rays, are not likely to be distinguished, for one would be concealed in the matrix immediately beneath the transverse rays, whilst the other, projecting above the exposed surface, would inevitably be broken away. Consequently it is very difficult to determine positively whether the forms with four transverse rays exposed on the plane of the sponge-wall, represent the entire spicule—in which case it would be termed cruciform,—or whether one or both of the other rays of the normal spicules were originally present. Judging by the analogy of allied recent forms, it is probable that in most cases these spicules were furnished with a fifth ray at right angles to the other four. In the examples of Cyathophycus from the Utica shale, are distinct traces of a fifth ray in some of the larger spicules, and it can also be seen in detached spicules from the Quebec group.

"In both recent and fossil hexactinellids, many of the elongated filiform anchoring spicules terminate distinctly in four short recurved rays, and are thus five-rayed spicules in which one ray is greatly developed; but in other instances they have simple blunt or pointed ends, and may thus represent only one ray or one axis of the normal spicule. With the exception of two species, all the anchoring spicules present in the Quebec sponges seem to be merely pointed at their distal ends. In one species they are complex, consisting of several filaments twisted spirally.

"In recent hexactinellid sponges, in addition to the spicules forming the regular framework of the skeleton, there are much smaller spicules of varied forms, imbedded in the soft tissues. These, generally known as flesh-spicules, are very seldom met with in the fossil condition, but it is not improbable that the delicate film of pyrites, seen in places on the surface of the Quebec sponges, may arise from the replacement of the flesh-spicules by this mineral."

The species of sponges noticed below have been submitted to Dr. Hinde, author of the British Museum, "Catalogue of Fossil Sponges," and the following descriptions are largely based on his notes on the specimens. The magnified tracings of the structures in the text have usually been drawn under the camera to one scale (about five times the natural size). The restorations are based on comparison of the more perfect specimens, some of which are represented from photographs in Plate III. It is to be observed that the smaller cruciform spicules, though usually displaced, were in the living animals symmetrically arranged in the meshes. These smaller

spicules form secondary and tertiary structures within the larger areas formed by the primary spicules.

GENUS PROTOSPONGIA, *Salter.*

1.—PROTOSPONGIA TETRANEMA, S.N.[1]

(Figs. 1 to 4. Pl. III, figs. 1, 2.)

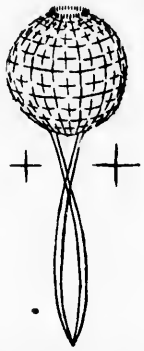


FIG. 1.—*Protospongia tetranema.* A small specimen restored.

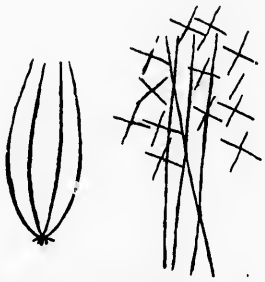


FIG. 2.—*Protospongia tetranema.* Anchoring spicules slightly enlarged.

In the specimens in which the outline of the sponge has been pr[illegible]ed, the body appears to have been elongated oval or rounded, measuring about 45 [illegible] in length by 30 mm. in width. There was an aperture at the summit, though it cannot now be distinguished, except in a few rare instances. The wall of the sponge appears to have

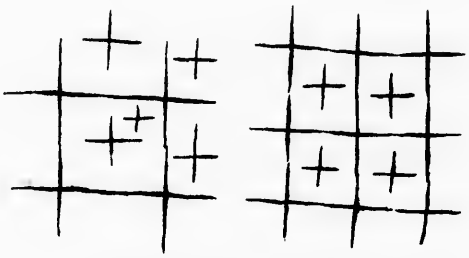


FIG. 3.—*Protospongia tetranema.* Primary, secondary and tertiary cruciform spicules, × 5.

consisted—as in the other species of this genus—of a single layer of cruciform spicules of various dimensions, disposed so as to form a framework with quadrate or oblong inter-

[1] The characters of this and several of the following species were given in "Notes on Specimens in the Peter Redpath Museum, 1888."

spaces. The rays of the larger spicules constitute the boundaries of the larger squares, and within these, secondary and smaller squares are marked out by smaller spicules. Judging by the length of the rays of the larger spicules, the larger squares would be about 5 mm. in diameter, whilst the smallest do not exceed 1 mm. The rays of the individual spicules slightly overlap, and it is probable that they may have been lightly cemented by silica at the points of contact. The rays of the larger spicules are conical, gradually tapering from the central node to the pointed extremity; whilst the rays of the smaller spicules appear to be nearly cylindrical. For the purposes of this paper the different orders of spicules, in these sponges, may be designated as primary, secondary and tertiary spicules.

From the base of the sponge, four slender elongated filiform spicules project. They are approximately cylindrical, pointed at both ends, from 0.1 to 0.25 mm. in thickness, and from 50 to 70 mm. in length. Their proximal ends are inserted apparently in the basal

Fig. 4.—*Protospongia tetranema* (?). Osculum enlarged, and surrounded by minute spicules.

part only of the sponge, and they project in the same direction, though not in lateral apposition with each other. In perfect specimens their distal ends converge and unite terminally. The root spicules in the larger specimens are about 6 cm. in length.

This species is one of the most abundant at Metis. In some specimens the spicular framework of the body of the sponge retains in places its natural arrangement; in others the framework has been almost entirely broken up, and the constituent spicules irregularly mingled and compressed together. But in every complete specimen there are four anchoring spicules occupying the same relative position to the framework or body-wall of the sponge, thus clearly showing that they are essential to the species. In the spicules of the body-wall only four transverse rays can be distinguished, but it is quite possible, as already mentioned, that a fifth ray may have been present. On one of the rock-slabs there is a detached spicule in which the fragmentary stump of a fifth ray can be clearly seen projecting from the central node of the transverse rays. The rays in this spicule are unusually long.

There can be no hesitation in placing this form in the genus *Protospongia*, since the same arrangement of the spicular mesh-work is present in it as in the type of this genus. In no other examples of the genus, however, has the presence of anchoring spicules been

recognised, owing, no doubt, to their imperfect state of preservation, and this feature may now be reckoned as one of the generic characters. In the present species, however, these anchoring spicules were very peculiar, and seem to have consisted of a cruciform spicule of which the rays were bent upward and lengthened, forming a stalk for the sponge. This would give a firm attachment, and adapt itself to the gradual rise of the bottom to which the sponge was attached. The mechanical properties of such an arrangement of spicula are obviously well suited to effect their purpose.

Salter, in his original description of Protospongia from the Cambrian of Wales, compares it with Acanthospongia of Griffiths from the Silurian of Ireland, the original specimen of which he had seen; but says it has six-radiate spicules. He also remarks that the spicules of Protospongia seem to be all in one plane.[1] *P. Major* of Hicks is a still older species, from the Lower Cambrian or Longmynd series, and seemingly of different structure and of much more open texture than that above described. Matthew has also noticed and figured fragments of Protospongia from the Lower Cambrian of St. John, New Brunswick. The present species, though somewhat later in age than the foregoing, has the merit of presenting a better state of preservation and better illustrating the general form, and more especially the root-spicules.

The following remarks are quoted verbatim from Dr. Hinde :—" There are some differences of opinion as to the character of the spicular mesh-work and the systematic position of Protospongia, and fresh light on the points contested is afforded by these Quebec specimens. It has been doubted whether the body-wall of the sponge merely consisted of a single layer of spicules, or whether this layer corresponded to the dermal layer in other sponges of this group, and, as in these, was supplemented by an inner spicular skeleton. The evidence of the Quebec specimens favors the view that the body-wall of the sponge consisted only of a single layer of spicules. Various opinions have likewise been held as to whether the body-spicules were free, and merely held in their natural positions by the soft animal tissues, or whether they were cemented together by silica at the points where their rays are in contact. Prof. Sollas, in an able paper on the structure and affinities of the genus (Quart. Journ. Geol. Soc., Vol. XXX, p. 366), asserts that they are separate, and not united either by envelopment in a common coating or, by ankylosis;' whereas it would seem that a certain degree of organic union must have existed to have allowed even the partial preservation of the mesh-work of the body-wall in the fossil state, and I have regarded the delicate film of pyrites, which extends over the mesh-work in many specimens, as indicating a connected spicular membrane which served to hold the larger spicules in position. From the study of the Quebec specimens I still think a certain degree of organic attachment existed where the spicular rays were in contact, but I am quite prepared to admit that it was not of the same complete character as in typical Dictyonine hexactinellids. Prof. F. E. Schulze has clearly shown that a certain degree of irregular coalescence takes place in the body-spicules of undoubted Lyssakine sponges, and now that we know that *Protospongia* was furnished, like most of the sponges of this group, with anchoring spicules, there is good reason to regard this and the allied Palæozoic genera as belonging rather to the Lissakine than to Dictyonine hexactinellids. This is the position assigned to them by Carter and Sollas."

[1] Journal Geol. Soc., vol. xx.

2.—Protospongia mononema, S.N.

(Figs. 5, 6 and 7. Pl. III, fig. 3.)

General size about one inch in diameter, originally globular but now flattened. Body spicules cruciform and more slender than those of *P. tetranema*. Superficial or defensive spicules very numerous and somewhat long and slender, so as to give a hirsute

Fig. 5.—*Protospongia mononema.* Restored.

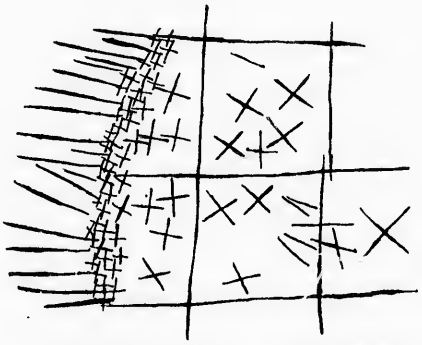


Fig. 6.—*Protospongia mononema.* Cruciform and protective spicules, × 5.

appearance and in flattened specimens often to obscure the body spicules. Root, single, stout, often three inches long, with two to four short spreading branches at base. These terminal spicules are flattened at the extremities. Hinde remarks that some specimens seem to have two or more anchoring rods; but in all or most of the specimens showing

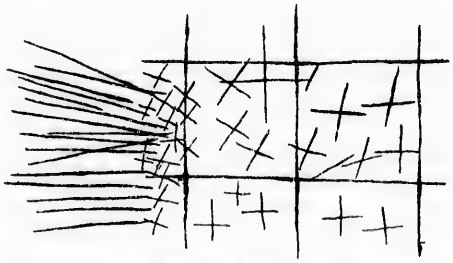


Fig. 7.—*Protospongia mononema.* Primary, secondary and tertiary spinules, × 5.

this appearance these seem to have been loose rods drifted into contact with the sponge. The anchoring rod in this species is often increased in thickness by a crust or frosting of pyrite, and this would seem to indicate that it had, like the modern Hyalonema, animal matter as well as silica in its composition.

This species is nearly as abundant as the preceding, and is often seen without the anchoring rods while the latter are also often seen detached.

In comparison with the previous species the root spicules are not only quite different, but the skeleton of the body differs in some important particulars. The cruciform spicules have somewhat longer arms and form wider meshes, while they are very slender and scarcely at all thickened at the nodes. The surface is also invested with very numerous superficial or protective needles, giving a hispid appearance at the edges, while the meshes of the central part are obscured by the superficial spicules flattened down on them. The form and character of the osculum or oscula have not been observed.

3.—Protospongia coronata, S.N.

(Figs. 8, 9, and 10. Pl. III, fig. 4.)

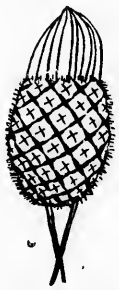


Fig. 8.—*Protospongia coronata.* Restored.

Fig. 9.—*Protospongia coronata.* Primary, secondary and protective spicules, × 5.

Body ovate, small, 2 cm. long, spicules coarse and four-rayed, so connected as to give the appearance by their obliquity of a diagonal network of rhombic openings. This may possibly be the effect of flattening. Numerous small cruciform flesh spicules. Root spicules strong, short or broken off, 2 to 4. Osculum large, terminal, covered with a conical hood made up of curved spicules converging to a point, and 1 cm. in height. A few short superficial spicules visible at the sides.

Fig. 10.—*Protospongia coronata.* Showing internal cavity.

This is a small but interesting species, remarkable not only for its conical hood, but also for the rhombic meshes and the development of the nodes of the larger cruciform spicules, as well as for the stoutness of the latter, their rays being much thickened toward the centres.

4.—Protospongia polynema, S.N.

(Figs. 11 and 12. Pl. III, fig. 5.)

This is a large sponge in great shapeless flattened patches, several inches in diameter though there are smaller individuals also. Body spicules fine and slender, making a very

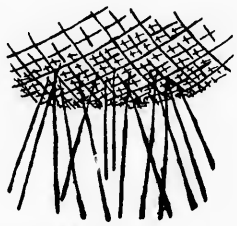


Fig. 11.—*Protospongia polynema.* Portion of base of large specimen.

open mesh. At base numerous simple root spicules, short, and, in some cases, expanded at their extremities. Young individuals seem to have been globular and probably sessile, while large individuals had a flat base, but the general form is greatly obscured by crushing, especially in the larger specimens.

Fig. 12.—*Protospongia polynema.* Primary, secondary and tertiary spicules, ×5.

It may be a question whether two species may not be included under the above specific name. The larger specimens have much more open meshes while the smaller are more hispid. These differences may, however, depend on age. I have attempted only a partial restoration of this species in fig. 11, as the specimens do not show with certainity the form of the upper part, which I imagine, however, had long protective spicules.

5.—Protospongia cyathiformis, S.N.

(Figs. 13 and 14. Pl. III, fig. 5.)

Fig. 13.—*Protospongia cyathiformis.* Restored.

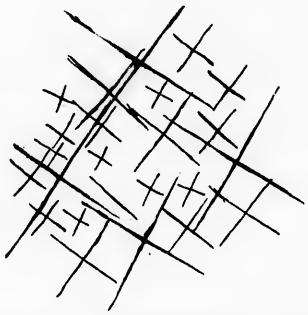


Fig. 14.—*Protospongia cyathiformis.* Primary, secondary and tertiary cruciform spicules, × 5.

General form inverted conical. When mature about 3 cm. wide at top and 5 cm. long without the anchoring spicules which are at least an inch long. Top truncate as if with a wide osculum, with a few short defensive spicules on its margin. Primary body spicules cruciform with long rays, in some 2 to 3 mm. in length, loosely attached or free, but forming large rhombic meshes, secondary and tertiary spicules numerous and delicate with slender arms. Root spicules short, simple, about five visible in the most perfect specimens and passing up to the middle of the body. Indications of many interior minute flesh spicules often constituting a pyritised mass, obscuring the meshes.

The oblique character of the transverse spicules deserves notice, but this may be the result of compression, though I think it more likely that it is an original feature.

This species is well characterised by its form, and by its multitudes of very minute cruciform spicules. These and the fact of the sponge being often represented by a dense pyritous mass indicate a thick and fleshy body-wall.

6.—Protospongia delicatula, S.N.

(Fig 15.)

Fig. 15.—*Protospongia delicatula.* (*a*) Restored. (*b*) Portion of base enlarged.

Globular or oblong in form, from 1 to 4 cm. in greatest diameter. Body spicules cruciform, very numerous, and extremely small. Some specimens show what seems to

be a wide osculum above, and very numerous slender anchoring spicules below. There are also indications that, in mature specimens, the general form sometimes became cylindrical or inverted conical, though specimens showing these forms are too imperfectly preserved to show the details of structure.

In this species and *P. cyathiformis*, the wall of the body seems to have been denser than in the other species and sometimes to have preserved its outward form, and this, with the multitude of minute spicules and the undeveloped condition of the spicular meshes of the skeleton, may possibly indicate a generic difference.

On this species Dr. Hinde remarks :—"This sponge has a subcircular outline ; the central area is vacant and there is often a relatively wide rim of a blurred mass of iron pyrites with an outer margin of fairly large cruciform spicules. The iron pyrites evidently represents a mass of spicules too small and too closely associated together to be separately distinguished in their replaced condition. The sponge is clearly hexactinellid and quite distinct from the others described above."

Genus CYATHOSPONGIA (*Cyathophycus*), Walcott.

7.—Cyathospongia Quebecensis, S.N.

(Figs. 16 and 17. Pl. III, fig. 7.)

Fig. 16.—*Cyathospongia Quebecensis.* Restored.

Fig. 17.—*Cyathospongia Quebecensis.* Base enlarged.

Form elongated conical, composed apparently of numerous long, vertical spicules, crossed by horizontal or annular bars, and with a few cruciform spicules in the meshes. The vertical and transverse spicules may be cruciform spicules arranged vertically. The form terminates downward in a blunt point with indications of a few short anchoring spicules. This species closely resembles *Cyathophycus* (*Cyathospongia*) *reticulatus* of Walcott

from the Utica shale, but differs in detail, especially in simplicity of the vertical rods and development of the transverse or circular bars. The largest specimens are 8 cm. long by 3 wide at top. There are signs of minute lateral defensive spicules. The general form and structure resemble those of the modern sponges of the genus *Holascus*.

The species *Cyathophycus reticulatus* was founded by Walcott on specimens from the Utica shale, but, as it has not been thoroughly described, the following notes, for much of the material of which I am indebted to Dr. Hinde, may be useful :—

In the collection of minerals of the late Mr. J. S. Miller of Ottawa, purchased for McGill University, are a few fossils, some of them Canadian, others from the phosphate deposits of South Carolina. Among the former are a few specimens of Utica slate fossils, which, from their appearance I suppose to have been collected in the beds of that formation near Ottawa, though it is possible that some of them may have been obtained from the United States. They include a specimen of the above species, which Mr. Ami, who has collected extensively in these beds at Ottawa, informs me has not yet occurred to him. The specimen is a small slab of the ordinary Utica shale, having an impression of a glabella of Triarthrus on the back, which proves its geological horizon. It has two specimens of Cyathophycus close together, nearly perfect at their bases and broken off at the height of about three inches. They are perfectly flattened and pyritised, which is also the condition of other fossils in these shales, with the exception of the graptolites, which seem to have resisted this kind of change.

The genus *Cyathophycus* was originally described by Walcott from specimens obtained at Trenton, Oneida Co., New York.[1] He regarded it as an alga, whence the termination *-phycus;* but subsequently, in the 'American Journal of Science,' 1881, corrected this error, and referred it to the sponges. Hall (35th Regents' Report) properly places it with the reticulate sponges included in his family *Dictyospongidæ*, but does not add much to Walcott's original description, to which the present specimens permit some additions to be made.

The specimens are perfectly flattened, but show distinct indications of the two sides of the originally conical form. The wall of the skeleton has evidently been thin and composed of slender bundles, each of a few long simple spicules, and increasing both by bifurcation and the introduction of new bundles, so as to preserve nearly the same distances in the wider parts of the cone. They are very regular in the lower part, where there are about nine principal, with some intermediate secondary bundles in a centimetre, but they become more irregular toward the top. This may, however, be an effect of decay and crushing. At the base these bundles become thicker, and in a specimen from the original New York locality, kindly lent to me by Mr. Ami, I have observed that they become expanded and converted into somewhat short clavate root spicules. This is, however, not apparent in Mr. Miller's specimens, which may have been broken off at the surface of the mud.

The vertical bundles are crossed at right angles by horizontal spicules much less regularly arranged, but dividing the surface into rectangular meshes. These are slightly oblique and rhomboidal in the specimens, but this is probably due to pressure. The

[1] Trans. Albany Instit., 1879.

horizontal spicules seem to be triacerate in form, and much shorter than those of the vertical system, though of very different lengths. They are sometimes in bundles and sometimes solitary.

In parts of the substance, apparently within the reticulate wall, may be seen a few cruciform spicules, and flocculent patches apparently of very small spicules, which seem to have been mostly internal and most abundant toward the base, but cannot be distinctly made out.

The wall is very delicate, and consists of quadrate or oblong areas formed by slender longitudinal and transverse strands or fibres, of which the former are the more prominent. As in Protospongia, the quadrate areas are formed by the four transverse rays of cruciform, or five-rayed spicules, but these are disposed so that their rays overlap each other, and thus form fascicles of closely opposed parallel rays. The spicules in the transverse strands of the wall are less thickly grouped together, and even in some of the larger squares they may be arranged singly, whilst the smaller squares are generally bounded by single spicules only. The longitudinal strands principally consist of cruciform (?) spicules, but it is possible that elongated filiform spicules may likewise be present. There are plain indications of a fifth or distal ray in many of the principal spicules of the wall, shown by a very minute knob or blunted process projecting from the central node of the transverse rays, which may represent a partially developed ray, or the broken stump of a complete one. In some places, also, there is a continuous film of pyrites, probably indicating a membrane of very minute spicules or an agglomeration of flesh-spicules, now replaced by this mineral.

The basal portion of these specimens is incomplete, but there are indications of an extension of the longitudinal strands of the wall downward into a spreading tuft of short anchoring spicules widening at their distal ends.

This genus is mainly distinguished from Protospongia by the fascicular arrangement of the spicular rays in the principal longitudinal and transverse fibres. The regular quadrate areas of the body-wall also mark it off from *Plectoderma* and *Phormosella*, Hinde. (See Brit. Foss. Sponges, Part. I, Pl. III, figs. 1, 2 and Part. II, p. 124-5, Pal. Soc., 1886-37.) How far it may resemble *Dictyophyton*,[1] Hall, and the other genera associated therewith by Prof. Hall (35th Report of the State Museum, 1884, p. 165, pls. 18-21), it is impossible to state, for the structural features of this genus have not been sufficiently described, and the characters assigned to the other genera are mainly those of external form, which, as regards this group of sponges, are hardly of generic importance.

The structures of Cyathophycus, as shown in these specimens, bear a great resemblance to those of the recent genus *Holascus*, Schulze (Challenger Reports, Vol. XXI, p. 85), based on sponges dredged from depths varying between 1,375 and 2,650 fathoms in the South Atlantic and in the Southern Ocean.[2] There is a striking similarity in the struc-

[1] In the only species of the Dictyospongidæ in which I have seen structure, that named by Whitfield *Uphantenia Dawsoni*, Am. Journ. of Science, Aug., 1881, and Bulletin Am. Num. Nat. Hist., Dec., 1881, the spicules are appparently filiform and arranged in broad longitudinal and transverse bundles crossing each other, and with small, loose flesh-spicules in the meshes. The arrangement is therefore different in details from that of *Cyathophycus*, or, as it should now be called, *Cyathospongia*. The name *Hydroceras* proposed by Conrad, is liable to the objection that it was intended to indicate affinity to cephalopod shells.—J. W. D.

[2] Especially *H. fibulatus*, Schulze. Chal. Rep. xvi, fig. 9.

ture of the sponge-wall in the fossil and in the original specimens described by Schulze, now in the British Museum of Natural History.

The whole of the spicules, in the Utica as in the Quebec group specimens, are completely pyritised, and appear under the microscope to be made up of rows of cubical crystals of pyrites. They were probably originally siliceous, but this need not excite surprise, as the silica of such spicules is in a condition which facilitates solution, and in some modern sponges the spicules are not purely siliceous, but contain some animal matter. I have also noticed other cases in which siliceous Palæozoic sponges have experienced this change, while in many specimens the spicules have entirely disappeared.

This is the case with the Erian or Devonian sponges of the genus *Dictyophyton* and allied genera, which, owing to their apparently membranous character, I at one time believed to be fucoids, but abandoned this idea on seeing the specimen of Uphantænia (*Physospongia*, Hall), which Prof. Whitfield was kind enough to show me in the New York Museum in July, 1881. In a note communicated to Prof. Whitfield in August, 1881, I have made the following remarks on the pyritisation of sponges :—

" The most puzzling fact in connection with the original siliceous character of these sponges is their mineral condition, as being now wholly replaced by pyrite. Carbonaceous structures are often replaced in this way, and so are also calcareous shells, especially when they contain much corneous matter, but such changes are not usual with siliceous organisms. If the spicules were originally siliceous, either they must have had large internal cavities which have been filled with pyrite, or the original material must have been wholly dissolved out and its place occupied with pyrite. It is to be observed, however, that in fossil sponges the siliceous matter has not infrequently been dissolved out, and its space left vacant or filled with other matters. I have specimens of Astylospongia from the Niagara formation which have thus been replaced by matter of a ferruginous color; and in a bundle of fibres, probably of a sponge allied to Hyalomena from the Upper Llandeilo of Scotland (since named *Hyalostelia* by Hinde[1]), I find the substance of the spicules entirely gone and the spaces formerly occupied by them empty. It should be added that joints of Crinoid stems and fronds of Fenestella occurring in the same specimen with the Uphantænia are apparently in their natural calcareous state."

The type of structure of Cyathophycus is essentially that of the Hexactinellid sponges of the suborder *Dictyonina* of Zittel, and under this, as has already been suggested by Barrois, it belongs to the family of *Dictyospongidæ*, established by Hall for Dictyophyton and the allied sponges of the Erian rocks. This type, already known as far back as the Utica shale, is now carried a stage farther by our discoveries at Metis.

The sponges of the genus *Cyathophycus* are not abundant in the beds explored at Metis and most of them have been much broken up. Only one specimen was obtained as a tolerable state of completeness.

Genus ACANTHODICTYA, *Hinde.*

Sponges approximately subcylindrical in form, consisting of a skeletal mesh-work of longitudinal and transverse spicular strands or fibres. The longitudinal strands are

[1] I have similarly explained *Pyritonema* of McCoy and *Eophyton explanatum* of Hicks, as has Hinde also, in Geol. Mag., 1886.

composed of somewhat loosely arranged fascicles of elongated overlapping spicules, and the spicules of the slender transverse fibres are as a rule disposed in a single series. From the outer surface of the sponge, numerous spicular rays project outwards at right angles. The sponge appears to have been anchored by a basal prolongation of the longitudinal strands. Owing to the present compressed condition of the specimens it is difficult to determine the original form of the constituent spicules. Some of the elongated longitudinal spicules may be merely simple rod-like forms, others are clearly cruciform and their transverse rays form the cross-fibres. The spicular rays which form the projecting bristles of the surface may be the free distal rays of normal hexactinellid spicules, but only these projecting rays can now be clearly distinguished; the others are merged in the longitudinal fascicles.

The general structure of the skeleton resembles that of *Cyathospongia*, Walcott, but it is characterised by the presence of the projecting surface rays. The mesh is also of a looser character than in Cyathospongia and its arrangement in quadrate areas is only faintly recognisable.

8.—Acanthodictya hispida, *Hinde.*

(Figs. 18 and 19. Pl. III, fig. 8.)

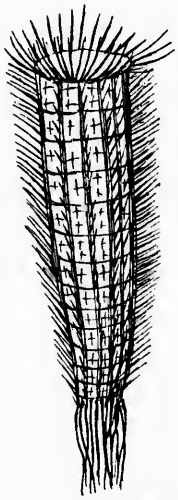


Fig. 18.—*Acanthodictya hispida.* Restored.

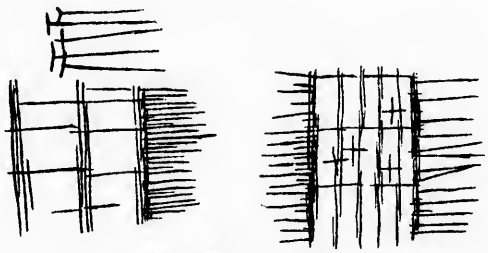


Fig. 19.—*Acanthodictya hispida.*—Portions enlarged × 5, showing framework and cruciform and protective spicules.

The examples of this species are apparently nearly cylindrical tubes from 30 to 50 mm. in length, and about 12 mm. in width. The longitudinal fascicles are about 1 mm. apart and the transverse fibres from 1 to 2 mm. distant from each other. The projecting spicular rays of the surface are only seen in these compressed sponges at the lateral margins as a sort of fringe. The free rays are somewhat thickly set; they vary from 5 mm. to 3 mm. in length; the longer forms in some instances occur at regular intervals, probably at the angles of the mesh, and between these are the shorter rays. The extremities of many of the larger forms are slightly swollen or club-shaped, but it is uncertain whether this is

an original feature or is due to an irregular deposition of the pyrites which has now in all cases replaced the silica.

This species appears as ribband-like bands composed of vertical and parallel bundles of delicate spicules with slender transverse spicules crossing them at intervals like the rounds of a ladder. It was probably originally cylindrical, but the extremities have not been seen, though fragments nearly three inches in length have been found. One of its most conspicuous characters is the possession of dense fringes of long protective spicules at the sides, and these seem to be based on a cortical structure of crutch-shaped or cruciform spicules from which the defensive spicules spring. Scattered cruciform spicules of small size appear also in the middle of the bands. The fascicles of longitudinal spicules are sometimes loosely twisted in a spiral manner, and it is probable that the root-fibres were spiral.

Sponges of the above species are sometimes associated with the larger masses of Protospongia in such a manner as to suggest a parasitic or commensal relation, but this may be accidental, and may arise from the cortical spicules of Acanthodictya becoming entangled with the surface of neighbouring sponges.

It is possible that some of the spirally twisted anchoring rods mentioned below may have belonged to this species, but its root spicules have not been seen attached.

The genus no doubt approaches to Cyathospongia, but is separated by its cylindrical form, the fascicled character of its longitudinal rods, and its cortical spicular arrangements.

Genus HYALOSTELIA, *Hinde.*

9.—Hyalostelia Metissica, S.N.

(Fig. 20.)

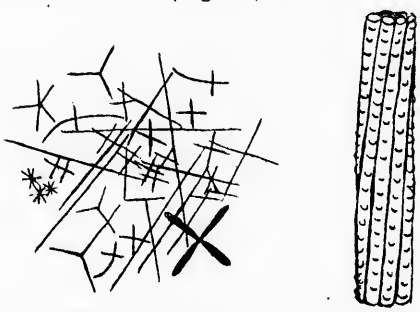


Fig. 20.—*Hyalostelia Metissica.* Spicules × 5, and large spiral anchoring rod magnified.

This species has not yet been seen in a perfect state or showing its general form. It seems to have been of a specially friable or decomposable character. The body appears as irregular patches of broken up skeleton, which, under the lens show a confused mass of cruciform spicules large and small, slender rods and some peculiar triradiate spicules, apparently in some cases with oblique angles, though this may perhaps be a result

of distortion, cruciform spicules with one ray curved, and minute stellate spicules. The whole somewhat resembles, though with difference in detail, the debris of the body of the modern Hyalonema, when crumbled and examined under the microscope. Associated with these patches, and also found separate, are many large anchoring rods of peculiar structure. They consist of several slender spicules twisted together so as to resemble a rope. Each strand has little tubercles externally to give greater holding power, and the whole, when well preserved, constitutes one of the most beautiful of sponge structures. In one or two cases the spiral threads were seen to be unwound at their proximal ends, as if passing into the slender rods of the body of the sponge. A tendency to such spiral rolling appears in the modern glass-rope sponge (*Hyalonema Sieboldii*), and the little frills on its root spicules may represent the tubercles of the strands in the present species. A similar structure has been found by Dr. Hinde in the root spicules of *Hyalostelia fasciculus*, McCoy, from the Siluro-Cambrian,[1] and a specimen apparently of the same species in my collection shows this structure, though less perfectly than the specimens from Metis.

The connection of these anchoring rods with the patches of scattered spicules is of course inferential, but they are constantly associated on the slabs of shale, and such roots are not found attached to any of the other species, though, as already stated, similar roots may have been present in Acanthodictya.

Imbedded in some of the patches of Hyalostelia are oval bodies, about a centimetre in their longest diameter, destitute of roots or defensives and composed of crowded cruciform spicules of minute size resembling those of *P. delicatula*. I was at first disposed to regard these as gigantic ovarian capsules, but Dr. Hinde thinks they are more probably small sponges of some other species accidentally introduced.

Genus LASIOTHRIX, *Hinde.*

Sponges small, depressed oval in outline, the outer surface covered by a layer of longitudinally arranged, apparently simple, acerate spicules; beneath this is another layer of spicules disposed transversely. From the base of the sponge several simple elongated spicules extend.

The peculiar arrangement of the surface spicules in this form indicates a probably new genus, but in its present condition one cannot tell with certainty whether it is monactinellid or hexactinellid. The outer surface seems to have been invested with a sheathing of regularly arranged acerate spicules, and beneath these other spicules, disposed transversely, can be distinguished, but whether these are really acerate or modified hexactinellid spicules there is no decisive evidence to show. In one or two instances, the spicules appear to be cruciform, and the presence of the long simple anchoring spicules extending from the base of the sponge, precisely as in normal hexactinellids, is a further point in favor of its belonging to this division.

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[1] British Fossil Sponges, Pal. Soc., 1888, Pl. i. fig 3.

10.—Lasiothrix curvicostata, *Hinde.*

(Fig. 21.)

The type form is transversely oval, 8 mm. in height by 12 mm. in width, the anchoring spicules can be traced to a length of 15 mm. from the body. The summit is rounded. There are some nodular elevations of pyrites in the body portion, but it is

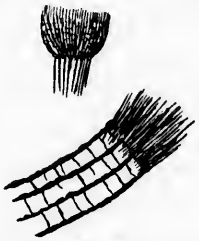

Fig. 21.—*Lasiothrix curvicostata.* Natural. size and portion enlarged

doubtful whether they represent aggregations of spicules or are merely due to the chemical deposition of the mineral, in connection with the presence of organic matter.

This curious little sponge, of which only one specimen was found, is remarkable for the strong curved spicules which support its sides, giving the appearance of a rounded basket with strong vertical ribs and very slender horizontal bars, within which and at top were quantities of slender straight spicules.

11.—Lasiothrix flabellata, S.N.

(Fig. 22.)

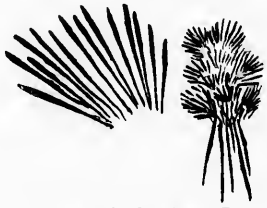

Fig. 22—*Lasiothrix flabellata.* Restored, and spicules × 5.

I have some doubt as to the right of this species to be placed in Dr. Hinde's new genus; but the specimens at first sight resemble the former species, and may accompany it provisionally. The surface appears to be covered with small ovoid bundles of stout biacerate spicules, diverging from the centre and sometimes in fan-shaped tufts. The specimens show indications of an external membrane, and they had somewhat strong root spicules, much larger than those of the body. It seems uncertain whether the fan-shaped bundles are really such or flattened groups of radiating spicules surrounding small oscula. In some specimens the spicules are confusedly scattered in films of pyrit-

ous matter with little indication of radiating arrangement. Dr. Hinde remarks as to this form that "the spicules do not stand out definitely, as in the case of the hexactinellid sponge spicules, but appear to be imbedded in some membrane. In two instances, anchoring spicules, like those of Protospongia, project from the base of the mass. I do not know of any monactinellid sponge furnished, as these appear to have been, with long anchoring spicules."

The sponges of this genus are very rare in the Metis collections, and are obscure and difficult to make out as to their details.

Genus HALICHONDRITES, *Dn.*

12.—Halichondrites confusus. S.N.

(Fig. 23.)

Fig. 23—*Halichondrites confusus.*
Spicules enlarged.

Oval or irregular masses of small simple spicules, imbedded in patches of pyrite, and without any definite arragement or root spicules, may indicate the presence of a halichondroid sponge. In the best preserved specimens the spicules appear to be biacerate and more slender and pointed than in the last, and they seem to be in two series, inclined at a very oblique angle to each other. In some specimens elongated spaces, with well-defined margins, are covered with thin films of pyrites, which may have resulted from the replacement or incrustation of a mass of minute spicules, of which traces remain in some places.

It is to be observed in this connection that sponges having originally much keratose or other dense animal matter would naturally aggregate in and around themselves a greater quantity of pyrite than those of a more purely siliceous character.

Miscellaneous Sponge Remains.

Under this head may be placed :—

(1) Surfaces covered with a confused mass of various kinds of spicules, probably the debris arising from the decay of numerous specimens, most of which probably belong to the species above described.

(2) Radiating groups of robust tapering spicules, some nearly an inch in length and quite thick at base. They resemble at first sight spines of Echini, but were no doubt siliceous, and belonged to sponges probably distinct from any of the species described above. The best specimen has a few small cruciform spicules at the base of the large

rods, which may indicate the character of the body of the sponge. (Fig. 24.) These spicules were probably defensive rather than for anchoring.

(3) Groups of extremely delicate simple straight spicules lying close together and parallel or more or less disturbed. They are narrow, and may have been cylindrical. One group has four long anchoring rods arranged in two pairs. They show no indication of cruciform spicules. (Fig. 25.)

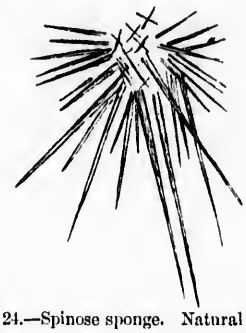

Fig. 24.—Spinose sponge. Natural size.

Fig. 25.—Group of spicules enlarged.

(4) Groups of fine slender spicules either parallel or divergent. Probably root spicules of some species of hexactinellid sponge, and not unlikely *Acanthodictya hispida* though there is no certainty as to this.

(5) Large and long solitary spicules, simple and straight, sometimes 0.5 mm. in thickness and several inches in length. They seem quite smooth, but are sometimes flattened at one end.

(6) Flattened masses of irregularly coalescent fibres like those of lithistid or corneous sponges. They show no anchoring spicules and are irregular in form, and have their structures very imperfectly preserved.

Nos. 2, 3, 5 and 6 are of rare occurrence in comparison with the other forms.

Other Organisms in the Same Beds.

Obolella (Linnarssonia) pretiosa, *Bill.*

(Fig. 26.)

Fig. 26.—*Linnarsonia pretiosa*, Billings. *a*, natural size of medium specimens, *b*, ventral, *c*, dorsal valves.

In my preliminary note this was compared with *O. Ida* of Billings, but according to Prof. Hall, who has kindly examined it, it belongs to the Cambrian genus *Lin-*

narssonia of Walcott, and is not distinguishable from *Obolella pretiosa* of Billings, from the Quebec group of the Chaudière River and Cape Rouge, near Quebec. It is allied to *O. sagittalis*, Salter, from the Welsh Menevian, and which also occurs in the zone of *Paradoxides Forchammeri* in Sweden. This genus is thus, so far as known, characteristic of beds older than the Levis; but there is no reason why it might not occur thus far up in the series. Shells of this species, usually pyritised, but sometimes black and flattened in the plane of the shale, abound in the layers holding sponges. I figure (Fig. 27), from drawings supplied by Prof. Hall, the structures of this little shell as they appear in some of the best specimens.[1]

Cystidean?—A small jointed stem, 1 cm. in length, with an elongated flattened mass at one end, in which, however, no distinct plates can be seen.

Trails of Annelids, etc.—On some surfaces are flattened and rounded grooves of different sizes, but mostly small, and which may be trails of aquatic animals of different kinds. They are not pyritous and present no trace of organic matter. Some of the larger are spiral in the manner of *Arenicolites spiralis*, and these are pyritous.

BUTHOTREPHIS PERGRACILIS, *Dawson.*

(Fig. 27.)

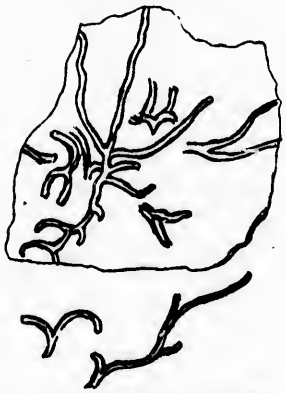

FIG. 27.—*Buthotrephis pergracilis.*

Stems very long and flexuous, about 1 mm. in diameter, and obscurely striate longitudinally; sending off at their extremities short alternate or opposite branches. Allied to *B. gracilis*, Hall, of the Siluro-Cambrian, but much more elongated and slender. These plants are replaced by pyrite and usually flattened, but the branches are occasionally cylindrical, which seems to have been the original form.

On some of the surfaces are groups of minute round pyritous spots, probably of organic origin, and perhaps ova or ovi-capsules of sponges or other animals, perhaps the vegetation or fructification of some aquatic plants. There are also a few oval or round, perfectly flat or smooth, discs resembling flattened vesicles. On some of the slabs are

[1] See appended Note.

also groups of more minute rounded bodies with no distinct structure, except in a few cases an apparent notch at the margin. They may be spore-cases or ova, but perhaps are not organic.

An interesting point in connection with these remains is the appearance of so many distinct types of siliceous sponges in one locality and formation, and this of so great age. It is also deserving of note that these sponges are of types usually occurring in deep water, and if we regard the dark shales containing them as deep-water deposits, this might account for the absence of other fossils. The alternation of these shales with coarse conglomerates and sandstones would also imply great oscillations of level at the time of their deposition.

The occurrence of so many species of sponges in very thin layers of shale, for the most part unfossiliferous, in connection with the obscure and unobtrusive character of these remains, is also an indication of the importance of thorough study of the older formations, and of investigation of even their more unpromising portions, as well as of the exhaustive exploration of those portions in which fossils occur.

NOTE.

Description of *Linnarssonia* cnf. *pretiosa*, Billings.

By Prof. James Hall, LL.D.

Shell small, subcircular or elongate transversely. Valves subequally convex, the ventral beak erect, slightly projecting and perforated at its apex. External surface covered with fine concentric lines, faint radiating striæ being visible on the interstitial lamellæ. The interior of the ventral valve bears a subtriangular or U-shaped ridge, the branches of which diverge anteriorly. The thickest portion of this ridge at the union of the branches is penetrated by the foraminal tube. In front of the foramen, and just within the cardinal line, on either side the axis of the shell is a conspicuous tubercle or boss. In the dorsal valve is a median ridge, extending half the length of the valve, and from this two short lateral ridges diverge, taking their origin at one-third the length of the median ridge from the posterior margin.

(The above description has been kindly supplied by Prof. Hall from specimens sent to him from the Peter Redpath Museum.—J. W. D.)