FIG. 1.—PROTOSPONGIA TETRANEMA, S.N.

Quebec group, Little Métis. Diagrammatic restoration, slightly enlarged.

PETER REDPATH MUSEUM, McGILL UNIVERSITY, MONTREAL.
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NEW SPECIES OF FOSSIL SPONGES, FROM LITTLE MÉTIS, PROVINCE OF QUEBEC, CANADA.

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PRELIMINARY NOTE ON NEW SPECIES OF SPONGES FROM THE QUEBEC GROUP AT LITTLE MÉTIS.

BY SIR J. WILLIAM DAWSON, LL.D., F.R.S.

Little Métis 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. These beds have afforded a species of *Retiolites*, allied to or identical with *R. ensiformis* of Hall[1], worm-burrows of various forms, including a spiral form similar to *Arenicolites spiralis*, and radiating markings of the kind elsewhere known as *Astropolithon*. A small species of *Obolella* also occurs, resembling *O. Ida* of Billings. In the conglomerates are limestone boulders, holding fragments of Trilobites of the genus *Solenopleura* and other fossils; but these seem to be of Middle Cambrian age, or considerably older than the beds in which they occur.

There can be no doubt, from the stratigraphical position

[1] Identified by Prof. Lapworth.

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 to the Trenton, and the beds are so much plicated that it is often difficult to unravel their complexities of arrangement.[1] At Métis, the evidence of the pebbles in the conglomerates indicates that they are newer than the Middle Cambrian, and the few fossils found in the sandstones and shales would tend to place them at or near the base of the Lévis division, or approximately on the horizon of the Chazy, or equivalent to the English Arenig. Lapworth, in his paper on "Canadian Graptolites," suggests that the sandstones holding Retiolites are older than this; but hitherto we have not found at Métis the characteristic Graptolites of the older or Matane series, which occurs further east, and is probably of Calciferous or Tremadoc age.

In the past summer, Dr. 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 considerable collections of these interesting fossils, which are now in the Peter Redpath Museum.

The locality of this discovery is the beach at the foot of the cliff below the Wesleyan church, where a considerable thickness of black shales appears well exposed. The section at this place is as follows, in descending order:—

1. A thick bed of hard sandstone or quartzite and conglomerate, forming the cliff immediately in front of the church, and shewing in some of the beds radiating markings (*Astropolithon*).

2. Black and dark gray shales, with a few calcareous bands—thickness about 100 feet. The black shales of this band hold sponges and layers of sponge spicules, with fucoids (*Buthotrephis*, of a new species,) and valves of a small *Obolella*. All of these fossils are usually in a pyritised state.

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

3. Flaggy sandstone and shale, about 20 feet.

4. Hard sandstone with quartz veins, 3 to 5 feet.

5. Hard gray shales and calcareous and dolomitic bands, with some layers sf 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 Mt. 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.

The sponges contained in Band 2 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 pyritization of spicules, once probably silicious, 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 have been 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 which case they will 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 form 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 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 collections include several species of sponges, Hexactinellid and Monactinellid; but, so far as observed, one of them is more abundant and better preserved than the others. The following may serve as a preliminary rough description of the species collected,—which will be more fully described and commented on by Dr. J. George Hinde, F.G.S., the author of the British Museum Catalogue of Fossil Sponges. See paper appended.

1. *Protospongia tetranema.* S. N. (Fig. 1)[1] The general form has been spheroidal, probably with an osculum or oscula at top. Root composed of four long spicules in two pairs, which diverge somewhat and then bend toward each

[1] This figure is a restoration, with two of the spicules enlarged. The defensive spicules and osculum are conjectural, being based merely on loose spicules and general form.

other and unite, forming a loop. General diameter, about 3 to 5 centimetres. Length of root-spicules, 6 to 7 centimetres, Wall of body apparently thin, composed of large cruciform spicules, stout at centre and tapering to sharp points, and arranged in square meshes, with smaller spicules of the same forms in the meshes. Length of largest spicules and size of meshes, 1 centimetre or less.

The structure of this sponge places it in Protospongia of Salter. It is true that the species of Protospongia are not known to have root spicules, but these must have been present in some form, and perhaps the bundle of spicules from the Menevian, described by Hicks as *P. flabella*,[1] may have been of this nature.

The root of this species is very peculiar in its arrangement. It seems to have been 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 on one plane.[2] *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.

[1] Hicks' Jour. Geol. Soc., Vol. xxvii.
[2] Journal Geol. Soc., Vol. xx.

2. A second species shows numerous large and long root spicules similar to those included in the genus *Hyalostelia* of Hinde. Some of them shew crutch-shaped terminations at the distal ends. Such remains of the body of the sponge as have been found, appear to consist of small cruciform and simple spicules, not unlike the *debris* of a modern *Hyalonema*. This sponge was larger than the preceding. It may be provisionolly named *H. Metissica*.

3. A third shews what seem to be remains of a thin-walled hollow sponge, with vertical and tranverse spicules arranged somewhat in the manner of those of the genus *Cyathophycus* of Walcott.[1] Like that genus, it contains also small loose cruciform spicules. It seems to have been conical and pointed below, and without long roots. It may be named *C. Quebecensis*.

4. Small ovoid masses of stout biacerate spicules, diverging from the centre and sometimes in fan-shaped tufts, seem to indicate a species of the genus *Lasiocladia* of Hinde. The specimens shew indications of an external membrane, and they had somewhat strong root spicules, much larger than those of the body.

5. Oval masses of small simple spicules, imbedded in patches of pyrite and without any definite arrangement of root spicules, may either indicate the presence of a halichondroid sponge, or of patches of spicules imbedded in coprolitic matter. The former is, perhaps, more likely to be the correct explanation.

An interesting point in connection with these remains is the appearance of so many distinct types of silicious sponges in one locality and formation. This fact was not distinctly noticed till the specimens were carefully examined, and it invites to further search in the locality, in hope of discovering new forms or more perfect examples of those represented in the present collection only by fragments.

[1] See note appended.

In the shales containing the above species, the only other fossils observed were slender fucoids, a small Obolella and a minute Cystidean or Crinoid, as follows :—

Obolella Ida? Billings.

I refer the specimens of Brachiopods found to this species, which belongs to the Lévis division of the Quebec Group. The valves are mostly pyritized, but sometimes flattened and then represented by a mere carbonaceous film. Mr. Whiteaves, to whom I have shewn these shells, agrees with me on their probable reference to one of Mr. Billings' smaller species from the Quebec Group.

Cystites?

A small-jointed stem one centimetre in length, with an elongated, flattened, oval mass at one end, in which, however, no distinct plates can be discovered.

Buthotrephis pergracilis. S. N.

Stems very long and flexuous, about one millimetre 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.

Note on Cyathophycus reticulatus. Walcott.

In the collection of minerals of the late J. S. Miller, Esq., of Ottawa, purchased for the 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, 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 pyritized, 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 *Dictyospongidae*, but does not add much to Walcott's original description, to which the present specimens permit some additions to be made.

[1] Trans. Albany Instit., 1879.

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 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 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 whole of the spicules are completely pyritized, 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 silicious, but contain some animal matter. I have also noticed other cases in which silicious 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 *Dictyophpton* 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 *Uphantenia* (*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 pyritization of sponges:—

"The most puzzling fact in connection with the original silicious 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 silicious organisms. If the spicules were originally silicious, either they must have had large internal cavities which have been filled with pyrite, or the original material must have been

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wholly dissolved out and its place occupied with pyrite. It is to be observed, however, that in fossil sponges the silicious 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 fibers, probably of a sponge allied to *Hyalonema* 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 *Uphantaenia* are apparently in their natural calcareous state."

The type of structure of *Cyathophycus* is essentially that of the Hexactinellid sponges of the sub-order *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 slate, is now carried a stage farther by our discoveries at Métis.

While the above paper was in the press, Dr. Selwyn was so kind as to send to me for inspection, through Mr. Ami, of the Geological Survey, some slabs of gray and dark coloured shale from the Quebec group rocks of the Chaudière River, in which spicules of sponges had been detected some years ago, by Mr. T. C. Weston and Mr. Willmot of the Survey, but which have not been published. The specimens show two forms of cruciform spicules, one with very slender rays and as much as a centimetre in measurement from point to point, the other stouter and measuring about five millimetres in extent, and therefore more nearly resembling those of *Protospongia tetranema*. There are also long

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

slender root spicules scattered on one of the slabs. On another specimen are large and strong forking spicules, the principal ray being about 1.5 centimetre in length, with a bulb or expansion at base, giving off two or more shorter and stout rays. They are quite different from any of the forms found at Metis.

These specimens are from beds referred to the Levis or Sillery formation, and are therefore approximately of the same age with those at Metis. They indicate the wide distribution of Hexactinellid silicious sponges in rocks of this period, and hold out the prospect of the discovery of additional species.

Mr. Ami also showed me a new sponge recently discovered by him in the Utica Shale at Ottawa. It consists of radiating groups of long slender simple spicules in a pyritized state. He hopes to make further collections from the same bed before describing these interesting forms, which resemble the spicules of the Pleistocene *Tethea Logani*, so common in the Leda clay of the St. Lawrence, but which may possibly be root spicules of a Hexactinallid sponge, as there are obscure cruciform spicules on the same slab.

Notes on Sponges from the Quebec Group at Mètis, and from the Utica Shale.

By George Jennings Hinde, Ph.D.[1]

Through the kindness of Sir J. W. Dawson, F.R.S., I have had the opportunity of studying a series of specimens of the fossil sponges lately discovered in the Quebec group at Little Métis by Dr. Harrington, and also of an example of *Cyathophycus reticulatus*, Walcott, from the Utica shale formation. The Metis specimens are specially interest-

[1] These Notes, kindly communicated by Dr. Hinde, arrived after the previous paper was in type; and are added without change. —J.W.D.

ing 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.

Sir J. W. Dawson has already given a preliminary account of the character and stratigraphical relations of the rock in which the sponges occur, as well as some details of the fossils themselves, and at his invitation I now add some further comments thereto.

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 coutinuous 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 silicious mesh, or whether they were merely held in their natural positions by the soft animal structures, and owe their present union to subsequent fossilization.

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 fossilization. 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, probably their basal portions were embedded in it, and 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 to a partial extent with one of the specimens of *Protospongia tetranema*. More frequently, however, probably owing to currents and other causes acting at the surface ef 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 gronp. 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 sub-order 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 a detached spicule on a slab 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 one doubtful exception, all the anchoring spicules present in the Quebec sponges are merely pointed at their distal ends.

In recent hexactinellid sponges, in addition to the spic ules 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.

Sir J. W. Dawson has already classified and given provisional names to the Quebec sponges, and it will therefore be more convenient for me to refer to their generic and specific details under these names.

Genus, PROTOSPONGIA, Salter.

Protoepongia tetranema, Dawson.

In the one specimen in which the outline of the sponge has been preserved, the body appears to have been elongated oval, measuring about 45 mm. in length by 30 mm. in width. Very probably there was an aperture at the summit, though it cannot now be distinguished. The wall of the sponge appears to have 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 interspaces; the rays of the larger spicules constituting 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 6 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 blunted extremity; whilst the rays of the smaller spicules appear to be nearly cylindrical.

From the base of the sponge, four slender elongated filiform spicules project. They are approximately cylindrical, pointed at both ends, from .1 to .25 mm. in thickness, and from 50 to 70 mm. in length. Their proximal ends are inserted apparently in the basal wall only of the sponge, and they project in the same direction, though not in lateral apposition with each other. In some specimens their distal ends converge and appear as if united terminally, but this may be merely due to chance overlapping.

This species appears to have been the prevailing form at Métis. Four specimens have been sent to me; in two of these the spicular frame-work of the body of the sponge retains in places its natural arrangement; in the other two the framework has been almost entirely broken up, and its constituent spicules irregularly mingled and compressed together. But in every 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, one can be traced for 30 mm.

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 recognized, owing, no doubt, to their imperfect state of preservation, and this feature may now be reckoned as one of the generic characters.

There are also 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. Professor Sollas, in an able paper on the structure and affinities of the genus (Quart. Journ. Geol. Soc., Vol. 30, p. 366), asserts "that they are separate, and not united either by envelopment in a common coating or by ankylosis," whereas it has seemed to me 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.

Genus Cyathophycus, Walcott.

The two specimens of *Cyathophycus reticulatus*, Walcott, —the type species from the Utica shale*—exhibit the structural features so very clearly, that it seems desirable to refer to the generic characters, as shown in these specimens, before referring to the Métis specimens which have been placed in this genus.

The specimens are, as already described by Sir J. W. Dawson, compressed side by side on the surface of the same

*These specimens are from the collection of the late Mr. J. S. Miller, of Ottawa, and their locality is uncertain; but the formation is determined by a Trilobite on the same slab They perfectly resemble specimens from the original locality of Walcott in New York. J.W.D.

slab of shale; their spicules have been replaced by pyrites precisely the same as in the Métis specimens. The sponges were evidently vasiform, gradually increasing in width from the base upward, their summits have not been preserved, but with a length of 65 mm. they are 40 and 30 mm. in width, respectively. Owing to compression, the opposite walls are now nearly in contact, being only separated by a mere film of the shaly matrix, hardly half a millimetre in thickness. The shale has split in such a manner as to expose in some places the outer surface of the wall, and in others, the inner surface of the opposite wall.

The wall is very delicate, and consists of quadrate or oblong areas formed by slender longitudinal and transverse strands or fibers, 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 indlcations 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 the a tuft of anchoring spicules.

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 pt. i. pl. iii., figs. 1, 2 and pt. ii. p. 124-5, Pal. Soc., 1886-7.) How far it may resemble *Dictyophyton*,* Hall, and the other genera associated therewith by Prof. Hall [35th Report of the State Museum (1884) p. 465, pls. 18-21], it is impossible to state, for, so far as I am aware, the structural features of this genus have never 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, bears a great resemblance to that of the recent genus, *Holascus*, Schulze, (Challenger Reports, Vol. xxi., p. 85) based on sponges dredged from depths varying between 1375 and 2650 fathoms in the South Atlantic and in the Southern Ocean. There is a striking similarity in the structure of the sponge-wall in the fossil and in the original specimens described by Schulze, now in the British Museum of Natural History.

Cyathophycus Quebecensis, Dawson. (No. 3 of previous paper.)

One of the specimens thus named is the basal portion of an apparently elongated tubular sponge, the wall of which consists of cruciform spicules disposed in longitudinal and transverse fibres, as in the type of the genus. The specimen is too imperfect and the spicular mesh too broken up to permit of minute discription. On other rock-fragments are fibres or strands of straight elongated spicules, either parallel with each other or irregularly scattered over the

* If the spicular structure of *Dictyophyton* should prove similar to that of *Cyathophycus*, this latter named will have to be suppressed in favor of the former, which has the priority. Both these names, applied under the supposition that the organisms were plants, are alike unsuitable, and it might be advisable, as suggested by Prof. Whitfield, to reinstate Conrad's original name, *Hydnoceras*. [In the only species of the Dictyospongidæ in which I have seen structure, that named by Whitfield *Uphantenia Dawsoni* (Am. J.

surface and intermingled with detached cruciform spicules. These various forms may well have been the anchoring and body-spicules of examples of the same species, now disintegrated and compressed together.

Hyalostelia Metissica, Dawson. (No. 2 of previous paper.)

This species is based on detached cruciform and anchoring spicules, the latter somewhat more robust than those placed as *C. Quebecensis*. In the present fragmentary condition of these forms it is impossible to give a satisfactory description, and the species must be regarded as provisional until better specimens are discovered.

Sponges of uncertain character. (Nos. 4 and 5 of previous paper.

On some of the slabs from Métis are small oval compressed patches, apparently consisting of small fusiform acerate spicules, sometimes parallel, at other times crossing each other irregularly. They do not stand out definitely as in the case of the hexactinellid sponge spicules, but appear to be embedded 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. Sir J. W. Dawson has suggested a resemblance to *Lasiocladia*, but they do not belong to this genus.

In another specimen an elongated space about 50 mm. in length by 16 in width, with well-defined margins, is covered with a thin film of pyrites, which may have resulted from the replacement of a mass of minute spicules, of which traces remain in some places, but no structure whatever can be recognized in it now. Sir J. W. Dawson has provisionally named the fossil *Halichondrites*.

Science, Aug., 1881, and Bulletin Am. Num. Nat. Hist., Dec., 1881), the spicules are apparently filiform and arranged in broad longitudinal and tranverse bundles crossing each other, and with small, loose flesh-spicules in the meshes. They are therefore different from those of *Cyathophycns*, or, as it should now be called, *Cyathospongia*. *Hydnoceras* is liable to the objection that it was intended to indicate affinity to cephalopod shells. J. W. D.]

Strange Paper