

AMERICAN PALÆOZOIC BRYOZA.

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[Continued from Vol. 6., p. 92.]

DEKAYIA, Edwards and Haime.

This genus, founded by the eminent French authors, Milne Edwards and Jules Haime, upon their Cincinnati group species, *D. aspera*, is in many respects related to *Heterotrypa*, Nicholson, and *Dekayella*, Ulrich. In the remarks appended to my descriptions of the latter genera, I have already shown the points of difference in their structure. It is therefore quite superfluous to again discuss the generic affinities of *Dekayia*, but the following brief description of the genus, based upon the aggregate of characters presented by six different Trenton and Cincinnati Group species, is, I believe, of more value.

Zoarium growing upward from a more or less largely expanded basal attachment, into, rarely cylindrical, usually flattened branches, which occasionally may become sub-froudescent. Surface sometimes with low monticules, usually, however, nearly even. Cells with polygonal apertures, sometimes apparently consisting of one kind only, but more commonly a few interstitial cells may be detected, which are more especially developed between the individuals constituting the groups of larger cells, that always furnish a more or less conspicuous feature of the surface. Cell-walls always thin, sometimes excessively so, there being but one species (*D. trentonensis*, n. sp.) in which the tube-walls, as the tubes pass from the axial into the peripheral region, are more than only very slightly thickened. Spiniform tubuli in the typical species few, but very large, and not infrequently already present in the axial region of the zoarium. In other species (*D. appressa*, n. sp., and *D. paupera*, n. sp.) they are reduced in size, but their number remains about the same. In one (*D. multispinosa*, n. sp.), they are also comparatively small, but more numerous. When in good state of preservation, at certain stages in the growth of the zoarium, the cell-apertures over larger or smaller patches of the surface are covered by a thin calcareous pellicle. On such covered spots the spiniform tubuli are very conspicuous. Diaphragms straight, usually few, sometimes almost entirely absent, occasionally (in the peripheral region) from one half to one tube-diameter distant from each other.

The genus as above defined includes, beside the type species, five other forms, four of which are described in this number. On account of their simplicity of structure, inexperienced collectors will probably find some difficulty in distinguishing one from the other. It must, however be borne in mind, that the more simple these organisms are, the more important are their variations. In separating them from each other, the characters principally to be taken into consideration are the following : The growth of the zoarium; the size of the cells, and thickness of their walls; the presence or apparent absence of small (interstitial?) cells, and their distribution if present; the size and number of the spiniform tubuli; and lastly, the disposition and number of the diaphragms crossing the tubes.

For comparison I have figured (Pl. VI., fig. 5) a portion of a tangential section of *D. aspera*. It shows the isolated and remarkably developed spiniform tubuli characteristic of this species. The zoarium of *D. aspera* consists of a large basal expansion attached to foreign objects, from the surface of which from one to five sub-cylindrical primary branches arise, that vary in diameter from .4 to .8 of an inch. These are frequently and irregularly divided, until the zoarium has attained a height of four or five inches. The terminal branches are sometimes much flattened, usually however retaining a sub-cylindrical form, while their diameter varies from .2 to .5 inch. The surface is usually elevated into low and rounded monticules, four or five of which may be counted in the space of .5 inch. They are occupied by cells a very little larger than the average, scattered among which it is common to find a limited number of much smaller cells, that may be of the nature of interstitial tubes. Unless badly worn the spiniform tubuli constitute a conspicuous feature of the surface. About five occupy the space of .1 of an inch. Longitudinal sections show that the diaphragms are wanting in the axial region, and remote in the peripheral. The spiniform tubuli are readily recognized by their thick walls and slender cavity. As is the case in all the species of the genus, the walls often assume a peculiar beaded appearance, due to an alternation of light and dark shades of sclerenchyma.

Like the other species of the genus *D. aspera*, is restricted in its vertical range, which is from 300 to 325 feet above low water mark in the Ohio river, at Cincinnati, O. At this height fragments are quite common.

Until lately I was under the impression that Nicholson's *D. attrita* might be advantageously regarded as a distinct variety of *D. aspera*,

but the material now at hand proves this view untenable. Dr. Nicholson's specimens doubtlessly represent the terminal branches of a typical example of Edwards and Haines' species, the branches of that portion of the zoarium always being more strictly dendroid, and of smaller size than the primary ones.

Dekayia trentonensis, n. sp., is interesting, not only from the fact that it is the earliest species of the genus so far known, but also because its cell-walls are thicker than is usual, and closely resemble those of a *Heterotrypa*. On the other hand, its growth, few if any interstitial tubes, and the large size of the spiniform tubuli, in which respect the species almost rivals *D. aspera*, are characters pointing with much certainty to *Dekayia*.

Another interesting form is found in *D. paupera*, n. sp. In this species the cell-walls are excessively thin, and the spiniform tubuli are greatly reduced in size (*i. e.* compared with those of *D. aspera*). But its general appearance, the absence of interstitial cells, the distribution of the spiniform tubuli, and, more than all, its close relationship to *D. appressa*, confirm me in my opinion that it is properly referred to the genus.

DEKAYIA PELLICULATA, n. sp. (Plate VI., figs. 9 and 9a.)

Zoarium ramose, with smooth, thick, mostly rounded, sometimes slightly flattened branches, arising from a large basal expansion, and gradually tapering from the base, where their diameter varies from .5 to 1.0 inch, to their terminal ends, where the diameter is usually not over .3 inch. On well-preserved examples the cell apertures over large patches of the surface are covered by a thin pellicle, the cell walls appearing as only very faintly elevated lines upon its surface, while the surface extensions of the spiniform tubuli are more distinct and prominent than when the pellicle is wanting. About five may be counted in .1 inch. At distances apart of about .1 inch, the surface shows clusters of cells slightly larger than those of the average size, interspersed among which are small and unequal aggregations of much smaller cells, that in all probability represent the apertures of interstitial tubes. Cells with moderately thin walls, angular, those of the ordinary size varying in diameter from $\frac{1}{120}$ th to $\frac{1}{100}$ th of an inch, while that of those forming the clusters mentioned rarely exceeds $\frac{1}{90}$ th of an inch.

In longitudinal sections the tubes in the axial region have, as usual, excessively thin walls, and are only occasionally provided with an iso-

lated diaphragm, these structures becoming however more numerous in the peripheral region, where they cross the tubes at distances apart of from one half to one tube diameter. The cells turn very abruptly from the axial into the peripheral region, becoming at the same time slightly thickened, and proceeding in their course to the surface they follow a line drawn at a right angle to the longitudinal axis of the branch. In the peripheral region may be noticed quite a number of small, obscurely beaded tubes, in which the diaphragms are somewhat more closely set than in the proper zoecia, and always cross the tube at the periodic points of stricture. In other tubes again the diaphragms are remote and sometimes entirely wanting. On the whole the tabulation of this species is peculiar. The spiniform tubuli are always distinctly visible, and have the usual structure.

Tangential sections show that the cells are thin-walled, and more or less angular, that the spiniform tubuli are comparatively small, and occupy the angle of junction between every three or four cells, and that they are further isolated by being situated between two to four small interstitial cells. From five to fifteen of the latter also occupy the interstices between the larger cells of the clusters, which even in these sections are not very striking.

This species is distinguished from *D. aspera* externally by its more regularly dendroidal growth, smooth surface (so far as monticules are concerned), and less conspicuous spiniform tubuli. Internally the much more numerous diaphragms, and interstitial tubes, beside the smaller spiniform tubuli present weighty points of difference.

Formation and locality: Cincinnati group. Rather rare on the hills back of Cincinnati, O., and Covington, Ky., at an elevation of from 300 to 350 feet above low water mark in the Ohio river.

DEKAYIA TRENTONENSIS, n. sp. (Pl. VI., figs. 6 and 6a.)

Zoarium dendroid, branches slightly compressed, frequently dividing, and from .15 inch (terminal ends) to .4 of an inch (primary branches) in diameter. Entire height of zoarium probably not more than two and one half inches. Surface with low and rounded monticules, of which five may be counted in .5 inch. They are occupied by clusters of cells a little larger than those in the intermediate spaces; occasionally a few small, perhaps interstitial, cells occupy the summit. Cells with comparatively thick walls, and a diameter of about $\frac{1}{120}$ th of an inch, while the diameter of those in the clusters mentioned does not exceed $\frac{1}{90}$ th of an inch. The large spiniform tubuli are quite prominent and easily recognized.

Longitudinal sections show that the tubes in the axial region of the zoarium have very thin and somewhat flexuous walls, and are crossed by diaphragms from two to four tube-diameters distant from each other. They bend into the peripheral region with a gentle curve, the walls at the same time becoming thickened, and the diaphragms much more numerous; in the peripheral region the latter are placed at distances apart of from one fourth to one tube diameter. An occasional small tube is met with, which, as it does not differ in its tabulation from the ordinary tubes, is to be regarded as young. The spiniform tubuli are large and readily enough detected in these sections. They originate in the outer portion of the axial region.

In tangential sections the cell-walls in their fully matured condition are of moderate thickness, and present a median lucid line, on each side of which is a dark ring that immediately surrounds the cell-aperture. The latter represents the secondary deposit of sclerenchyma, while the lighter median line represents the original walls of the cells. The groups of larger cells are sometimes quite conspicuous on account of their size, and frequently a few small cells are incorporated within their limits. On account of the comparatively thick walls the spiniform tubuli are not so conspicuous, as they are when cut through a deeper level, where the cell-walls are thinner. They are isolated and occupy the point of junction between every three, four or five cells.

This species is probably most nearly allied to *D. aspera*, the surface characters of the two being very similar. *D. trentonensis*, however, is a smaller species, and more strictly dendroid. Internally they are distinguished by the thinner cell-walls, and much less numerous diaphragms of *D. aspera*.

Formation and locality: Collected by the author from the upper beds of the Trenton group, at Burgin, Ky., on the Cincinnati Southern Railroad. These strata I regard as equivalent to Safford's Orthis bed.

DEKAYIA APPRESSA, n. sp. (Pl. VI., figs. 7, 7a and 7b).

Zoarium in rare instances subfrondescent, usually ramose, and from one to three inches in height. Branches flattened, dividing frequently, from .3 to .4 of an inch in width, and from .15 to .25 of an inch in thickness. Surface without monticules, but presenting groups of cells somewhat larger than the average, at intervals of about .075 inch, measuring from center to center. When the pellicle is preserved, and this is often the case, the spiniform tubuli are, though rather small and few, apparent enough. But when the pellicle is not preserved

they are not readily detected. Cells thin-walled, and with the exception of the groups mentioned, in all probability consist of one kind only, those of the ordinary size having a diameter of $\frac{1}{130}$ th inch, while that of those in the clusters may exceed $\frac{1}{90}$ th inch. An occasional small cell is met with, that, though I much doubt it, may be of the nature of an interstitial cell.

Longitudinal sections show that the tubes in the axial region are nearly vertical, and that in their course to the surface they bend abruptly outward, their walls, which, as usual, are very thin in the axial region, becoming but slightly thickened as they enter the peripheral portion. Diaphragms are but rarely developed in the "immature," or axial region, and only from five to ten in the "matured" portion of a tube, where they are placed at distances apart of from one half to one tube-diameter. Occasionally a small and short tube may be detected in which the diaphragms appear to be a little more closely set than is the case in the ordinary tubes. The spiniform tubuli being few and of rather small size, are not a conspicuous feature in sections of this kind.

In tangential sections the cells are thin-walled and angular, the groups of larger ones being often very distinct (see fig. 7*b*, Pl. VI.) On account of the thin cell-walls the spiniform tubuli, though of comparatively small size, are very apparent, occupying the angles of junction of every three, four or five cells.

The frequently branching, sometimes anastomosing zoarium of this species, does not resemble very closely any associate form. Some of the smaller specimens of *Dekayella ulrichi*, Nicholson sp., occurring over two hundred feet lower in the series, bear some external resemblance to fragments of *D. appressa*. The numerous interstitial tubes, and rounded cell-apertures of the former, amply serve the purpose of distinguishing them.

Formation and locality: Cincinnati group, at Cincinnati, Ohio. Rather common at an elevation of about 425 feet above the Ohio river. Its vertical range is restricted to only a few feet.

DEKAYIA PAUPERA, n. sp. (Pl. VI., figs. 10 and 10*a*.)

Zoarium ramose, the more or less flattened branches growing upward from a large and thinly expanded base, to a height of one and one half inches or a little more; varying in thickness from .15 to .3 of an inch, and in width from .2 to .8 of an inch. Surface without monticules. Cells polygonal, with excessively thin walls, the ordinary

ones having a diameter of about $\frac{1}{120}$ th of an inch. At intervals there are distinct groups of large cells, some of which have a diameter exceeding $\frac{1}{70}$ th of an inch. True interstitial cells are apparently wanting, the few small cells occasionally seen being doubtlessly young ones. The spiniform tubuli I have not been able to detect at the surface. Pellicle not observed.

In longitudinal sections the excessively thin-walled tubes in the axial region are seen to be crossed by few remote diaphragms. The tubes approach the surface with a gentle curve, the thickening of the walls that usually takes place as they enter the peripheral region, is scarcely perceptible in this species. The diaphragms are quite numerous in the "mature" or peripheral region, being about one tube diameter distant from each other. When the section passes through the spiniform tubuli they are, despite their small size, readily detected by the thickened appearance they give to the cell-walls between which they are placed. I have not been able to find any traces of interstitial tubes.

Tangential sections of this species are remarkable for excessively thin-walled angular cells, between every five or six of which the spiniform tubuli, which are smaller than in any other species of the genus, and inconspicuously isolated. The groups of large cells, mentioned in the description of the surface characters, are of course, quite distinct in this kind of section.

This species is closely allied to *D. appressa* in its growth and general features. Under the hand glass that species is seen to have somewhat smaller cells, less conspicuous clusters of large cells, and thicker tube-walls. Internally the much smaller spiniform tubuli of *D. paupera* will serve to distinguish them.

Formation and locality: Cincinnati group. Quite rare near the tops of the hills back of Cincinnati, O., where it appears to be restricted to a vertical range of only a few feet, somewhere between 375 and 400 feet above low water mark.

DEKAYIA MULTISPINOSA, n. sp. (Plate VI., figs. 8 and 8a.)

Zoarium dendroid, branches somewhat flattened, from .25 to .6 inch in diameter. Surface not raised into monticules. Cell apertures often covered by a pellicle, upon the surface of which, and over the angles of junction of the cells, the numerous, but comparatively small spiniform tubuli are sharply elevated. Even when the pellicle is absent these spines are very readily detected under a hand glass. At intervals of about .1 of an inch, measuring from center to center, are clus-

ters of cells slightly larger than the average. Between the individual cells composing these groups, there are always a greater or less number of much smaller interstitial (?) cells, which are sometimes aggregated in sufficient numbers to constitute "maculæ." Cells with moderately thin walls, those of the ordinary size about $\frac{1}{180}$ th of an inch in diameter, while that of those in the clusters mentioned does not exceed $\frac{1}{90}$ th of an inch.

In longitudinal sections the tube-walls are seen to differ but slightly in thickness in the axial and peripheral regions. Diaphragms are very sparingly developed, no tube, so far as I have been able to observe, being provided with more than two or three, throughout its length. The spiniform tubuli may be observed in large numbers, with the usual structure. None of the smaller tubes differ in their tabulation from the ordinary ones, and we may therefore assume, with some certainty, that true interstitial tubes are absent. The bending of the tubes from the axial into the peripheral regions is quite uniform and gradual.

Tangential sections show that the ordinary cells have thin walls, those of the slightly larger cells in the clusters described, being somewhat thicker. The spiniform tubuli are somewhat variable in size, and very numerous for a species of *DeKayia*, since nearly every angle of junction between the cells is occupied by one. A variable number of small cells is always present. These are, however, mostly developed between the large cells of the clusters. What their nature is doubtful, but, as before intimated, it is highly probable that they are only young tubes.

The large number of spiniform tubuli will serve to distinguish this species from all the other forms of the genus known to me. In its other characters the species is quite closely allied to *D. aspera*.

Formation and locality: Cincinnati group. Rare at an elevation of about 425 feet above low water mark in the Ohio river, on the hills back of Cincinnati, O.

PETIGOPORA GREGARIA, n. gen. et. sp. (Pl. VII., figs. 3, 3a, 3b and 3c.)
Gen. char. *ante* vol. v., p. 155.

Zoarium consisting of small patches usually from .1 to .3 of an inch in diameter, and .04 inch in thickness, adhering to foreign bodies. Nearly all of my specimens are attached to *Heterotrypa frondosa*, D'Orl. A narrow, usually smooth, but sometimes slightly wrinkled, germinating membrane forms the outer margin, which is

slightly elevated, and developed in advance of the young marginal cells. Surface without monticules, and covered uniformly by the apertures of equal sized cells, twelve or thirteen of which, are ranged in a series .1 of an inch in length. Interstitial cells wanting. Spini-form tubuli may be detected on well preserved examples by viewing the cells obliquely. In all cases, however, they project so little that they are easily overlooked.

Longitudinal sections show that the tubes in the central portion of the zoarium are vertical, those nearer the margin being inclined at an increasing angle. Their walls, when not including one of the large spiniform tubuli, are moderately thin, and often somewhat flexuous. The epithelial membrane is very thin and generally undulated. Diaphragms appear to be wanting.

Tangential sections show that, with the exception of an occasional young tube, the cells are of nearly uniform size and of one kind only. Between the angles of junction, the majority of which are occupied by the comparatively large spiniform tubuli, the walls are thin and appear to be amalgamated, no divisional line being visible between the walls of adjoining cells.

The genus *Petigopora* is established for the reception of at least four, and probably five Lower Silurian species, only one of which, the *Chaetetes petechialis*, of Nicholson, has been heretofore described. Two are now described for the first time, the type species *P. gregaria*, and *P. asperula*. The remaining species I hope to be able to describe at some future time. The principal characters of the genus are: (1), the large and numerous spiniform tubuli; and (2), the limitation of the growth of the colonies to small, individualized patches, which if brought into contact by lateral development, do not fraternize, but either raise a non-poriferous epithelial barrier, or leave a narrow unoccupied space between them. One of the undescribed species occurs in the shale washings of the upper strata of the Cincinnati group, as small subglobular masses, rarely exceeding .1 of an inch in diameter. This peculiarity of growth is due to the fact that the colony invariably selects some minute fragment of a shell or other foreign body, for a nucleus, which is eventually entirely covered. Its spiniform tubuli are numerous, and being of large size they are remarkably prominent, when in a good state of preservation.

Petigopora gregaria is readily distinguished from all the parasitic *Monticuliporidae* of the Cincinnati group, by its non-poriferous, sometimes concentrically striated marginal band, which is always preserved.

and much more distinct than it is in any other species of the genus. From the latter the type species is further separated by its smooth often concave upper surface.

Formation and locality : Cincinnati group. Rather rare on the hills back of Cincinnati, O., at an elevation of 425 feet above the river bed. The range is not positively known, but I found two groups of zoaria nearly 300 feet lower in the series.

PETIGOPORA ASPERULA, n. sp. (Pl. VI., figs. 4, 4a, 4b and 4c.)

Zoarium adhering to foreign objects, such as the shells of *Strophomena alternata*, etc., consisting of thin subcircular expansions, from .2 to .5 of an inch in diameter, and .03 to .08 of an inch in thickness. The surface is studded with small conical elevations, arranged in quite regular intersecting series, six or seven in the length of .4 of an inch. They are occupied by cells but slightly, if at all, larger than those of the ordinary size ; it is usual, however, to find the apices occupied by one or several spiniform tubuli often considerably larger than those in the intervening spaces. Cells small, somewhat unequal in size, from thirteen to fifteen in the length of .1 of an inch. The cell-walls are moderately thin between the angles of junction of the cells, the majority of these being occupied by very large and prominent spiniform tubuli.

Longitudinal sections show numerous spiniform tubuli, the proper tube-walls moderately thin, and no diaphragms. The tubes are at first inclined, but soon bend upward and proceed in a direct line to open at the surface.

In tangential sections the cell walls between the numerous spiniform tubuli, are quite thin, and occasionally preserve in a faint manner the divisional line between adjoining cells. The walls are somewhat thicker, and the spiniform tubuli larger than ordinary, in the groups of cells occupying the monticules at the surface.

This species does not resemble either *P. gregaria*, or *P. petechialis*, very closely, differing from both of those species in having distinct monticules and more conspicuous spiniform tubuli. *P. petechialis* forms very small conical zoaria, never, so far as I have been able to observe, more than .12 of an inch in diameter. Its vertical range is extended, I having collected typical specimens in the Upper Trenton rocks of Kentucky, and at nearly all elevations in the Cincinnati group. The range of *P. asperula* is much less extended, being apparently restricted to the strata between 300 and 450 feet above low water mark in the Ohio river.

Formation and locality: Cincinnati group. Not uncommon on the hills back of Cincinnati, O., and Covington, Ky.

LEPTOTRYPA, n. gen.

Zoaria thin, incrusting foreign bodies, occasionally overgrowing the latter and becoming partially free. Cells polygonal, thin-walled, apparently of one kind only. Surface with monticules or without, usually, however, showing more or less distinct groups of large cells. Spiniform tubuli small, numerous, generally occupying only the angles of junction of the cells. Diaphragms wanting or but sparingly developed.

Type, *L. minima*, n. sp.

This genus includes a group of species that I have found it quite impossible to distribute among the genera of *Monticuliporidae* already established. They can not be placed with *Atactopora*, the species of that genus being provided with spiniform tubuli which are always placed within the substance of the cell-walls, and project prominently into the cell-cavity, so as to give it a petaloid appearance. In *Leptotrypa* they are always situated *between the walls*, and are only rarely developed excepting at the angles of the cells. They have but little affinity with the species of *Spatiopora*, the cell-structure in the two genera being quite different.

Tangential sections of *Leptotrypa* somewhat resemble those of certain species of *Amplexopora*, but they differ so widely in growth, and other respects, that I am forced to regard them as quite distinct. How nearly *Leptotrypa* is allied to *Nebulipora*, McCoy, I am unable to say.

I have in vain tried to gain something like a satisfactory knowledge of the species upon which McCoy founded his genus. Specimens said to be *Nebulipora papillata*, prove, upon investigation, to belong to a species of *Ceramopora*. Even if an examination of McCoy's types, which may no longer be possible, should show the above identification of his species to be erroneous, and my genus a synonym, I ought not to be blamed, for, after carefully considering the question, I have come to the conclusion, that to propose a new genus for the reception of my species, will cause less confusion than to place them into a genus, the characters of which no one seems able to define with any degree of certainty.

Beside the four species next described, I propose to include in the genus *Leptotrypa*, *Chatetes discoideus*, James (Nicholson), and two Niagara group species, which Hall has, erroneously I believe, placed in his genus *Palæschara*, under the names of *P. affula* and *P. maculata*.

A very peculiar group of species, which I shall, provisionally, also include in this genus, is found in the *Monticulipora calceola*, Miller and Dyer, *M. clavacoidea*, James (Nicholson), and an undescribed form. Though I have seen of the first at least a thousand specimens, and of the other two several hundred, I have not detected any evidence going to show that they have grown upon a foreign object. On the contrary, the special form of the central cavity, assumed by each of the three species, is apparently due to the amount of curvature adopted by the tubes in their course from the point of gemmation to their apertures. In *M. calceola* the zoæcial tubes are always quite strongly curved, in consequence of which the zoarium takes a turbinate form, the gradually enlarging internal cavity being enrolled in a plane, and often making nearly two complete volutions. In *M. clavacoidea*, the tubes are straight, and proceed in almost a direct line to the surface. The form of the zoarium is therefore straight. In the undescribed species, which in 1880 I catalogued under the name of *Chatetes concavus*, the tubes curve but slightly, and the resulting form of the zoarium is concavo-convex, the cavity which in *M. calceola* is strongly curved, and straight in *M. clavacoidea*, being represented in *L. (?) concava*, by an oval impression. The internal structure of the cells and tube-walls of these species is, in all respects, very closely like that of *L. ornata*, and as such a structural similarity is of more importance than differences in the mode of growth, I have concluded, provisionally, to unite them with *Leptotrypa*.

LEPTOTRYPA MINIMA, n. sp. (Pl. VI., figs. 2, 2a and 2b.)

Zoarium consisting of very thin expansions adhering parasitically to the shells of a small species of *Orthoceras*, which are usually entirely covered by this delicate bryozoan. The surface shows at intervals of about .08 of an inch, abruptly elevated, small, conical monticules, two or three hundredths of an inch in diameter, and a little less in height. Their arrangement is often quite regular, in longitudinal and transverse or intersecting series. Their slopes are occupied by cells but slightly, if at all, larger than the average, while the summits often carry the apertures of a variable number of much smaller cells, which, if the specimen be worn, may give the monticules a sub-solid appearance. Cells $\frac{1}{180}$ th to $\frac{1}{120}$ th of an inch in diameter, angular, and thin-walled. The spiniform tubuli are to be observed only in well-preserved examples, their position being indicated in such specimens by a slight elevation of the junction angles of the cells, above the general level of the cell-aperture.

In longitudinal sections (Pl. VI., fig. 2*b*), the tubes are seen to be at first somewhat prostrate, but they soon rise and proceed directly to the surface. Their walls are moderately thin, and quite straight. Diaphragms are usually absent, an isolated one is, however, occasionally met with. Excepting the point of size, no difference can be detected between the ordinary tubes and the small ones mentioned in describing the monticules. On account of the filling of the tubes with the surrounding shaly matrix, the minute characters, which under other circumstances would be distinct, are often much obscured, if not obliterated.

Tangential sections (Pl. VI., fig. 2*a*), show that the angles of the cells are somewhat thickened and occupied by a small spiniform tubuli, which, if the section be taken from an inferiorly preserved example, may be overlooked. The cell-walls between the angles are thin, and in the state of preservation accessible to me, show no divisional line, those of adjoining cells being apparently amalgamated with one another. A variable though never large number of small cells, which our present information demands we should regard as either young or aborted, are irregularly interspersed among the ordinary cells, but oftener aggregated between the cells occupying the surface monticules.

All the specimens of this species seen by me, and their number is not less than three hundred, are without an exception, attached to a small species of *Orthoceras*, from two to four inches in length, and from .3 to .6 of an inch in diameter, at the larger end. The small conical monticules, and flat interspaces of *L. minima*, will distinguish it from the other species of the genus, as well as from all the rest of the parasitic *Monticuliporidae* of the Cincinnati group, with the exception, perhaps, of some of the species of *Atactopora*. These are, however, readily distinguished by their spiniferous and inflected cell-walls.

Formation and locality : Cincinnati group. Not uncommon in the shaly beds at Hamilton, Ohio, at an elevation equivalent to 350 feet above low water mark in the Ohio river, at Cincinnati, O. It is rare at the Cincinnati quarries.

LEPTOTRYPA ORNATA, n. sp. (Pl. VI., figs. 4 and 4*a*.)

Zoarium parasitically attached to *Cyrtolites ornatus*, the entire shell of which it covers with a thin expansion, from .02 to .10 of an inch in thickness. Surface smooth, but presenting at intervals of .1 inch, measuring from center to center, groups of cells that are conspicuously

larger than those in the intervening spaces, their diameter often exceeding $\frac{1}{80}$ th of an inch, while that of the ordinary cells is about $\frac{1}{120}$ th of an inch. Cell-walls thin, with the angles of junction slightly elevated.

In longitudinal sections (Pl. VI., fig. 4a) the tubes are thin-walled, and proceed abruptly from the attached epithelial membrane to the upper surface. Diaphragms may be absent or developed in limited numbers. The center of the walls is often traversed lengthwise by a delicate light line, indicating the central cavity of the spiniform tubuli.

Tangential sections (Pl. VI., fig. 4) often show a delicate dark line separating the thin walls of adjoining cells, which at nearly all their angles of junction, is enlarged so as to include a small spiniform tubulus. Both these and longitudinal sections show, that with the exception of the larger cells already described, the cells consist of one kind only.

This is a common species at the top of the hills back of Cincinnati, O., where over nine tenths of the specimens of *Cyrtolites ornatus* found are covered with it. The thin zoarium may sometimes be flaked off, so as to expose the beautifully cancellated shell of that gastro-pod.

Formation and locality: Cincinnati group. At Cincinnati, O., and other localities where the strata marking the 420 ft. level above the Ohio river are exposed.

LEPTOTRYPA CLAVIS, n. sp. (Pl. VI., figs. 3 and 3a.)

Zoarium growing parasitically, usually upon crinoid columns, but not infrequently upon the stems of small branching bryozoa. In thickness it varies from .02 to .15 of an inch, the largest specimen seen being about one inch in length. Those growing upon the crinoid columns usually become club-shaped or subfusiform, while those on other objects are variously and irregularly shaped. Surface presenting at intervals of .1 inch, small clusters of cells a little larger than the average, which in a few specimens are slightly elevated above the general level of the surface. Cells of one kind only, rather unequal in size, and irregular in arrangement, with moderately thin walls, and an average diameter of $\frac{1}{130}$ th of an inch, while the diameter of those in the groups seldom exceeds $\frac{1}{100}$ th of an inch. When in a good state of preservation the spiniform tubuli are quite prominent and pointed, and being numerous, give the zoarium a characteristically hirsute appearance.

Longitudinal sections (Pl. VI., fig. 3a) show a spiniform tubulus between nearly all of the thin and straight tube-walls. Their internal

cavity is distinctly shown and comparatively large. Diaphragms are usually developed at remote intervals, though often wanting. No interstitial tubes have been observed.

In tangential sections (Pl. VI., fig. 3) the cells are seen to be thin-walled and of rather unequal size. Spiniform tubuli of moderate size are plentifully developed, placed at the cell-angles and often at points between, in which cases the walls are forced into their respective cell-cavities on each side. No special series of small cells are observed in these sections.

This species is probably most nearly allied to *L. ornata*, from which it differs principally in having more numerous spiniform tubuli, which are also much more conspicuous, both externally and internally. These differences will also apply to the other species.

Formation and locality: Cincinnati group. A common species in the lower 200 feet of strata exposed at Cincinnati, O., and elsewhere.

LEPTOTRYPA CORTEX, * n. sp.

Zoarium attached to the shells of *Orthoceras* and *Endoceras*, over which it forms large expansions, from .02 to .08 of an inch in thickness, and several inches in length. Surface smooth, but with distinct clusters of cells, larger than the average, at intervals of .15 of an inch, measuring from center to center. The cells are moderately thin-walled, and quite regularly hexagonal, those of the ordinary size having a diameter of about $\frac{1}{95}$ th of an inch, while that of the largest in the clusters rarely exceeds $\frac{1}{60}$ th of an inch.

Longitudinal sections show that the tube-walls, just above the epithelial membrane, are very thin; nearer the surface they are somewhat thickened, and show the line of demarcation separating the walls of adjoining tubes, and an occasional spiniform tubulus. Diaphragms are quite numerous, those in the upper part of the tube being about one half a tube-diameter apart, which distance is gradually increased in the lower portion to more than one tube-diameter. Interstitial tubes are entirely absent.

Tangential sections show quite distinctly the divisional line between the tubes, while the angles are usually enlarged to admit what I now regard as spiniform tubuli. They are generally represented only by a dark triangular space, but a few also show a minute central lucid spot,

*The figures of this species were unfortunately overlooked in preparing the plates for this number. Being a species of some importance, I was unwilling to strike it out of this connection, proposing to make my description valid by figuring its characters in my next installment.

such as characterizes these structures in other forms. The cell-walls are moderately thin, and as a rule hexagonal, though five and seven sided tubes are not uncommon.

This species is distinguished externally from *L. ornata*, by its larger and more regularly arranged cells. Internally we find a greater number of diaphragms in the tubes of the former, than in those of the latter species.

In many respects *L. cortex* is closely related to such species of *Monotrypa*, as *M. petasiformis*, Nicholson, and *M. filiosa*, D'Orbigny. I am, however, slowly becoming convinced that those species do not really belong to the genus *Monotrypa*. They differ from *M. undulata*, Nicholson, the type of that genus, in several important features. In *M. petasiformis*, for instance, the tubes of the zoarium are divided into two distinct regions, equivalent to the axial and peripheral regions of the ramose *Monticuliporidae*. The tubes in the axial or lower portion of the zoarium have very thin walls, and are crossed by remote diaphragms, which further up in the peripheral region become numerous and often crowded, while at the same time the walls are appreciably thickened, and show a distinct line of demarcation separating adjoining tubes. The structure of *M. undulata* is quite different, its zoarium being, in a measure, homogeneous throughout, and incapable of being divided into similarly differentiated regions. In this connection it is important to note that a number of more or less distinct forms, differing, however, in no essential features from *M. undulata*, occur in Upper Silurian, Devonian, Lower Carboniferous, and Coal measure deposits, a fact going to show, that, though simple in structure, the genus *Monotrypa* is characterized by peculiarities distinct enough to be preserved throughout all the great divisions of the Palæozoic rocks, an extent of range enjoyed by but few of the genera of the *Monticuliporidae*. What to do with *M. petasiformis* and *M. filiosa*, I am not yet prepared to say, being unwilling to admit them into the genus *Leptotrypa*. Their structure being very similar to the most typical species of *Monotrypella*, it might be well to extend the limits of that genus so that they would be included.

Formation and locality: Cincinnati group. Specimens of *L. cortex*, are rather rare in the lower 200 feet of strata exposed at Covington, Ky., and Cincinnati, O.

DISCOTRYPA, n. gen.

Gen. char. *ante* vol. v., p. 155.

The type of this genus, and its only known representative was

described by me in the second volume of this publication, under the name of *Chaetetes elegans*. The zoarium of this species consists of a free and very thin circular expansion, with an average thickness of .02 of an inch, the diameter of the few specimens found varying from .4 to 1.2 of an inch. The under surface is covered by a smooth or concentrically striated, thin epitheca. The upper surface is elevated at intervals of .14 of an inch, measuring from center to center, into low and rounded monticules, the bases of which may be said to be in contact, since the interspaces are concave. Their arrangement is in concentric series around the central monticule, each being occupied by cells which gradually enlarge in diameter from $\frac{1}{110}$ th of an inch at the base to $\frac{1}{60}$ th of an inch at the summit. The cells have thin walls, are rhomboidal or hexagonal in shape, and arranged in regular decussating series, that remind one strongly of the cell-arrangement in *Ptilodictya pavonia*. D'Orb. In longitudinal sections (Pl. VII., fig. 1a) the tubes are seen to proceed to the surface with a slight inclination; the walls are of medium thickness, and show more or less distinctly the original line of demarcation between adjoining tubes. Two or three diaphragms cross each tube, on lines parallel with the upper surface. Tangential sections (Pl. VII., fig. 1b) show that the cell-walls of adjoining tubes are not fused together, the line of separation being quite distinct. On each side of this central line is the original wall, which is usually thickened inwardly, by a thin secondary deposit of sclerenchyma. The cells occupying the monticules are marked by thinner walls, being cut at a deeper level than those in the intervening space. Sections of this species prove that interstitial cells are entirely absent, no young or small cells of any kind having been observed. Spiniform tubuli are also wanting.

Discotrypa elegans is a rare fossil in the Cincinnati group, at an elevation of 300 feet above low water mark in the Ohio river, at the quarries back of Cincinnati, O., and Covington, Ky.

The genus is probably more nearly allied to *Leptotrypa* than to any other genus of the *Monticuliporidae*. They are, however, amply distinguished by the difference in their cell structure, different habits of growth, and the absence of spiniform tubuli in *Discotrypa*.

ASPIDOPORA ARCOLATA, n. gen. et sp. (Pl. VII., figs. 2, 2a, 2b and 2c.)

Gen. char. *ante* vol. v., p. 155.

Zoarium consisting of very thin, convex, free expansions, from .3 to 1.0 of an inch in diameter, and about .025 of an inch in thickness. The under surface is marked with radiating striæ, and sometimes with obscure concentric wrinkles. The upper or celluliferous surface

presents a variable number of slightly convex and irregularly angular spaces with an average diameter of about .15. At the margin of these convex spaces the cell-apertures are circular, and $\frac{1}{110}$ th of an inch in diameter. The cell-apertures gradually become broadly elliptical, and larger as the centers of the spaces are approached, where the largest have a diameter of $\frac{1}{80}$ th inch. The apertures of the cells are often closed by a centrally perforated, thin operculum. The interstitial spaces are occupied by the elongated apertures of very shallow interstitial cells. The spiniform tubuli are quite numerous and prominent.

In longitudinal sections (Pl. VII., fig. 2c) the proper tubes are prostrate for half their length, when they bend upward and proceed directly to the surface. Their walls are thin and more or less flexuous, especially upon the concave side of the tube. The interstitial tubes are developed from the upper wall of the prostrate portion of the proper zoecia, and enlarge very rapidly, so as to attain their full size, at the second diaphragm. In the proper tubes the diaphragms are present only in the lower half of the tube, where it is crossed by two or three. At their apertures a very thin calcareous line representing the opercula mentioned may sometimes be detected. In the interstitial tubes the diaphragms are crowded. The spiniform tubuli are first developed near the cell-apertures, where if carefully looked for, a variable number may be detected. A second layer of cells is often found above the first.

Tangential sections (Pl. VII., fig. 2b) show that the cells have very thin walls, those of adjacent tubes being entirely separated, or in contact only at limited points. Their diameter becomes greater as the center of the convex spaces or monticules is approached, while they at the same time vary their shape from sub-circular to oval or elliptical. The interstitial spaces are occupied by large, usually hour-glass-shaped interstitial cells, which are occasionally divided into halves by a very faint wall. Comparatively large spiniform tubuli are developed at all the points where the true cells come in contact.

This species in growth somewhat resembles *Prasopora* (?) *newberryi*, Nicholson, and the closely allied *P. calycula*, James (*Diplotrypa calycula*, Nicholson). Both those, however, have a smooth, and evenly convex upper surface, while the under surface is only concentrically, and not radially striated.

Formation and locality: Rare in the shales just above low water mark in the Ohio river at Cincinnati, O. My specimens were collected on the banks of the river Ohio, in the first ward of the city.

SPATIOFORA ASPERA, n. gen. et. sp. (Pl. VII., figs. 5, 5a and 5b.)

Gen. char. ante vol. v., p. 155.

Zoarium parasitically attached to the shells of *Orthoceras*, over which it forms large, but very thin expansions, never, so far as observed, exceeding .05 of an inch in thickness. Cells oblong, of very irregular shapes, more or less unequal in size, with an average diameter of $\frac{1}{95}$ th of an inch. At intervals of about .15 of an inch the surface exhibits clusters of larger cells, some of which may attain a diameter of $\frac{1}{60}$ th of an inch. These groups are not so conspicuous on account of their size, as for the aggregation of the remarkably developed spiniform tubuli, which, being also distributed between the ordinary cells, give the entire surface a very rough appearance. The cell-walls when not enlarged by the spiniform tubuli are thin.

Longitudinal sections (Pl. VII., fig. 5b) are remarkable for the very unequal thickness of the cell-interspaces. This peculiarity is due to the fact that on one side of the tube the divisional wall is simple and thin, while on the other side it may be much thickened by one of the spiniform tubuli. Diaphragms appear to be wanting.

In tangential sections (Pl. VII., fig. 5a) the cell-walls are of variable thickness, and traversed by peculiar interrupted, dark streaks, that give these sections a marked resemblance to similar sections of the Lower Silurian *Ceramoporidæ*. The walls of adjoining tubes are apparently fused with one another. The cell-cavities are irregularly shaped, and often indented by an inflexion of the wall.

The genus *Spatiopora* is established to receive seven Lower Silurian species. Four of these are now described for the first time, the fifth was described and figured by Edwards and Haime in 1850, under the name of *Chatetes tuberculatus*, the sixth is about to be published by Mr. Arthur Foord in the next publication of the Canadian Survey; while the seventh must for a time remain unpublished. The affinities of the genus are directly intermediate between the *Ceramoporidæ* and *Monticuliporidæ*, the external appearance of the cells and zoarium in general being like that of other parasitic genera of the latter, while the internal structure of the walls is precisely like that of the most typical species of the former family. To decide to which of these two families the genus most properly belongs, can not, at this time, be done with any certainty, and as I have not yet figured any of the *Ceramoporidæ*, I will postpone my comparisons, until I shall have done so.

S. aspera, the type of the genus, is easily distinguished from this species by its rough surface.

Formation and locality: Cincinnati group. Comparatively rare at

Hamilton and Cincinnati, O., at an elevation of about 375 feet above low water mark in the Ohio river.

SPATIOFORA MACULOSA, n. sp. (Pl. VII., fig. 6.)

Zoarium forming large and very thin parasitic expansions, usually adhering to the shells of *Orthoceras*, but in a few instances to other objects. The surface shows at intervals of .18 inches, measuring from center to center, distinct groups of large cells, which, very rarely, however, are slightly elevated above the general level of the surface. The diameter of the cells in these clusters not infrequently exceeds $\frac{1}{5}$ th of an inch, while that of the ordinary cells averages about $\frac{1}{10}$ th of an inch. The cell-walls are moderately thin, and at many of the angles are elevated into more or less prominent spiniform tubuli, which are larger and somewhat more numerous among the cells of the clusters mentioned. The cell-apertures are more or less irregular in shape, and never, on account of the thickened wall angles, are strictly angular. Interstitial cells are entirely absent. The internal structure shows no striking peculiarities, and much resembles that of the type species.

This species is not uncommon in the Cincinnati Group. It is distinguished from *S. aspera* by the more distinct groups of larger cells, smaller and less prominent spiniform tubuli, which are only to be observed in finely preserved examples, the greater number of specimens found being entirely smooth.

Formation and locality: To be found at most localities in the Cincinnati group, but it can not be said to be common at any.

SPATIOFORA LINEATA, n. sp. (Pl. VII., fig. 7.)

Zoarium consisting of excessively thin expansions, adhering to the shells of *Orthoceras*. Cells rounded, or oblong, arranged in regular longitudinal series, and in somewhat less regular transverse or intersecting rows. There are no monticules nor distinct groups of larger cells; the cell-walls between the slightly elevated intersections are quite thin; measuring along one of the longitudinal series nine or ten cells may be counted in the space of .1 inch. On account of the extreme tenuity of the zoarium, the sections prepared of this species are unsatisfactory.

This species is readily separated from the other non-tuberculated species of the genus by the regular arrangement of its cells in longitudinal series. From *S. tuberculata*, Edwards & Haime, sp., which sometimes assumes a similar cell arrangement, it is distinguished by its smooth surface, the zoarium of that species being elevated at intervals into rather large monticules.

Formation and locality : Cincinnati Group. Rather near the tops of the hills back of Cincinnati, O., and at Hamilton, O.

SPATIOPERA MONTIFERA, n. sp. (Pl. VI., figs. 1 and 1a, and Pl. VII., fig. 8.)

Zoarium parasitically attached to the shells of *Orthoceras*, over which it forms a thin and expanded crust ; from .02 to .05 of an inch in thickness. Surface exhibiting a number of long, narrow monticules, all drawn out in one direction, and arranged in more or less regular longitudinal and diagonally intersecting series. The long diameter of these monticules varies from .17 to .35 of an inch, their width rarely exceeding .1 of an inch, their height varying from .05 to .1 of an inch. Four or five may be counted in the length of 1 inch. The cells over all portions of the surface are subequal, moderately thin walled, sub-angular, with an average diameter of $\frac{1}{90}$ th of an inch. A variable number of minute cells is usually placed among the cells occupying the monticules.

Tangential sections (Pl. VI., fig. 1) are remarkable for the peculiar wall structure, already noticed in *S. aspera*. But in this species the light and dark shades of the wall contrast so strongly, and are so intermingled that in some places the walls have a spongy appearance. A few spiniform tubuli were observed. Longitudinal sections (Pl. VI., fig. 1a) show that an occasional diaphragm is present. A few irregularly constricted, small or interstitial tubes may be noticed, in which the diaphragms are numerous.

I have little doubt that when Dr. Nicholson wrote the description of *Chatetes corticans*, which he now regards as identical with Edwards and Haines' *Chatetes tuberculatus*, he had before him three different species, of which *S. montifera* was one. The other two were typical *Chatetes tuberculatus*, and the form which was described by me in this JOURNAL as *Atactopora maculata*. As, however, Dr. Nicholson has abandoned his name *C. corticans*, I have deemed it more advisable to give this form a new name than to re-establish an abandoned one. *S. montifera* is distinguished from *S. tuberculata*, Ed. & H., as well as from all the parasitic bryozoa of the Cincinnati group, by its remarkably developed monticules.

Formation and locality : Cincinnati group; rather rare in the upper layers of the Cincinnati group, at Clarksville, Oxford, and other localities in Southwestern Ohio. It is not found at Cincinnati or any equivalent localities.

[TO BE CONTINUED.]

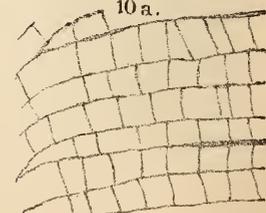
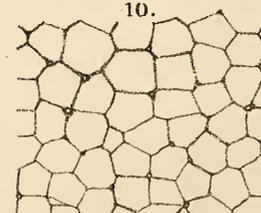
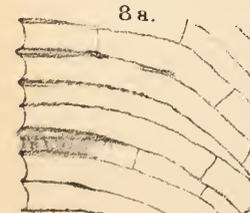
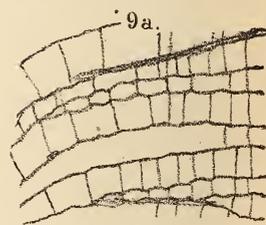
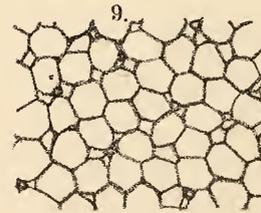
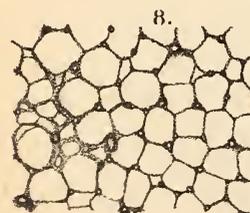
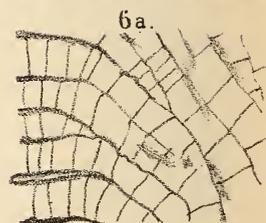
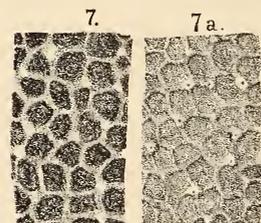
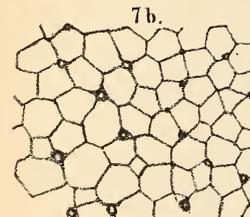
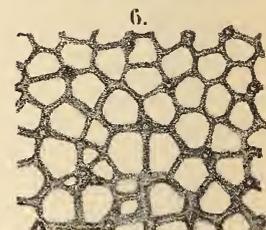
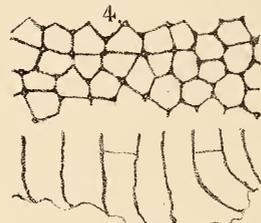
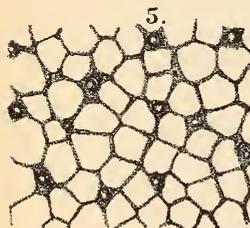
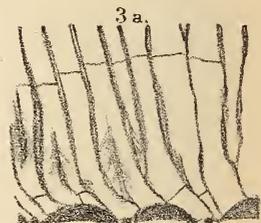
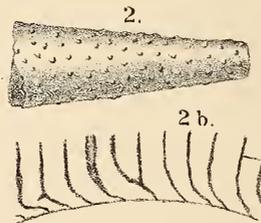
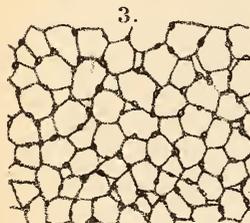
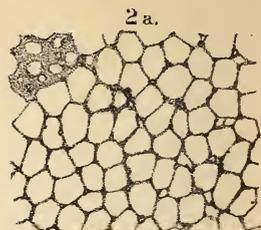
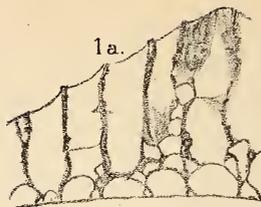
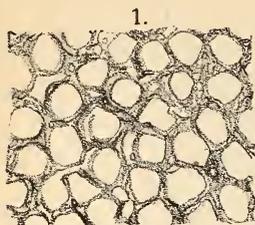


PLATE VI.

All the figures excepting fig. 2, are enlarged to 18 diameters.

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