

NEW LOWER SILURIAN BRYOZOA.

BY E. O. ULRICH.

(Read by title January 7, 1890.)

THE Bryozoa described in this paper are mainly from the Trenton Shales of Minnesota, where they were collected during the month of October, 1887. All the specimens are in the author's cabinet.

VINELLA, n. gen.

This genus is proposed for an adnate form supposed to be a Ctenostomatous bryozoan, with relations to *Vesicularia*, Thompson, and probably also to *Mimosella*, Hincks.

Zoarium attached to foreign bodies (shells, etc.), consisting of exceedingly slender, ramifying, thread-like tubes, occasionally arranged in a radial manner. Surface of tubes often faintly lined longitudinally. A row of widely separated small pores along the center of the surface of the tubes. Zoëcia unknown. Type, *Vinella repens*, n. sp.

As interpreted by me, the fossils for whose reception this genus is proposed represent the stoloniferous part of the bryozoan only. The zoëcia I regard as having been deciduous, and developed by budding from the creeping stolons at the points now represented by the small pores.

Named in honor of Mr. G. R. Vine, of England, who was the first to suggest the relation of *Rhopalonaria* and *Ascodictyon* to the Ctenostomatous Bryozoa.

## VINELLA REPENS, n. sp.

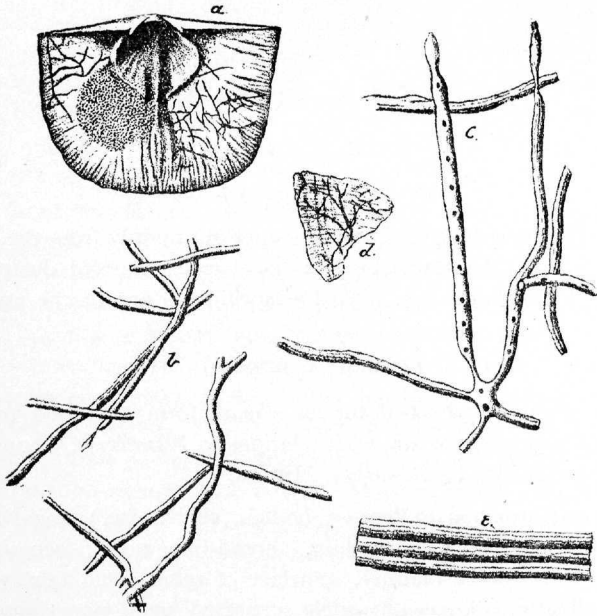


FIG. 1.—*Vinella repens*, n. gen. et sp. *a*, two colonies attached to the inner side of the ventral valve of a thin variety of *Streptorhynchus filitextus*, Hall. *b*, part of one of them magnified eighteen times. The pores are absent, probably not having been preserved. *c*, Part of another portion of same, X18, showing a central point with five divisions of the tubular stolon radiating from it. This portion of the specimen also preserves the pores, marking the points where the zoëcia were attached. *d*, another specimen attached to fragment of shell. *e*, small portion of same where three tubes lie parallel with each other. No pores could be made out on this specimen, but the longitudinal lines are more distinct than on the other specimen.

Zoarium repent, the stolons delicate, thread-like, often longitudinally striate, straight or flexuous; from 0.06 to 0.11 mm. in diameter; bifurcating often and sometimes arranged in a radical manner about a central node. Where best preserved, very small pores arranged uniserially along the center of the upper surface of the threads; about eleven in 2.5 mm. Zoëcia unknown, probably deciduous.

Similar organisms occur in Cincinnati, Wenlock and Chester groups. Being undescribed, comparisons would be useless.

Position and locality: Upper beds of the Trenton Shales at St. Paul, Minn.

## STOMATOPORA TENUISSIMA, n. sp.

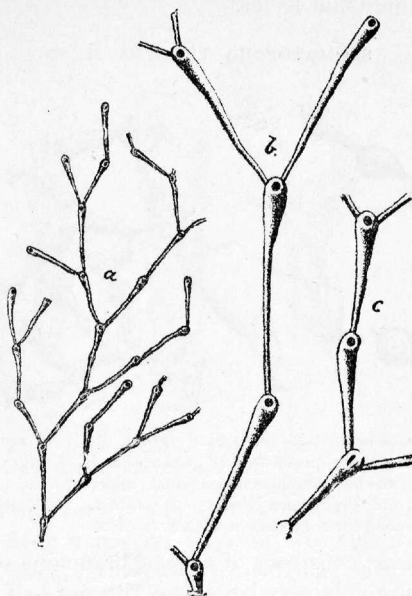


FIG. 2.—*Stomatopora tenuissima*, n. sp. and *S. proutana*, Miller. *a*, portion of zoarium of *S. tenuissima*,  $\times 7$ , showing its slender zoecia and mode of growth; *b*, several zoecia of same magnified eighteen diameters, to show their apertures and form more clearly. *c*, several zoecia of one of the most slender examples of *S. proutana* seen. Introduced for comparison.

Zoarium adnate, consisting of frequently branching uniseriably arranged zoecia. Zoecia exceedingly slender, about seven in eight mms., each from 1.0 to 1.5 mm. long, usually increasing very gradually from the proximal end, where the diameter is about 0.04 mm., to near the slightly bulbous anterior or upper end, which varies from 0.11 to 0.18 mm. in diameter. Aperture circular, small, about 0.05 mm. in diameter, situated very near the anterior end of the zoecium.

This and *S. turgida* illustrate the extremes of difference in shape and size of the zoecia of *Stomatopora* so far noticed. *S. tenuissima* is closely related to *S. proutana*, Miller, but its zoecia are much longer. Miller's species, with scarcely any modification, ranges from low in the Trenton (Birdseye limestone) to the top of the Cincinnati group.

Position and locality: Toward the top of the Utica horizon of

the Cincinnati group at Cincinnati, Ohio, 150 to 175 ft. above low water mark in the Ohio River.

STOMATOPORA TURGIDA, n. sp.

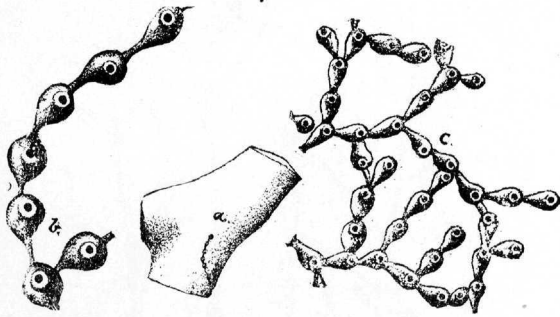


FIG. 3.—*Stomatopora turgida*, n. sp., and *S. inflata*, Hall. a, zoarium of *S. turgida*, growing upon *Pachydietya splendens*, Ulr., natural size. b, same enlarged to seven diameters, showing the swollen zoecia and small apertures. c, small portion of the zoarium of the turgid Cincinnati variety of *S. inflata*, Hall, also magnified seven diameters. Introduced for comparison with *S. turgida*.

Zoarium adnate, consisting of a single branching series of zoecia. Zoecia comparatively very large, the anterior half much swollen, rapidly tapering posteriorly with the slender, tubular proximal end inserted beneath the turgid anterior end of the preceding zoecium. Five zoecia, in five mm.; length of each zoecium varying from 0.85 to 1.30 mm.; the greatest diameter of the anterior half from 0.4 to 0.6 mm. The longest cells are the least turgid, while the shortest are the most. Apertures round, bordered by an elevated margin, small, 0.1 mm. in diameter, and situated about one-fourth of the length of a zoecium from its anterior end.

I have a number of specimens of this species, and all consist of comparatively few zoecia. Nor do the series of cells in any of them branch often, from which it appears that the production of two "gems" was a much less frequent occurrence than in the related *S. inflata*, Hall. (See Fig. 3, c.) *S. turgida* is further distinguished from that and all other species of the genus known to me, by the much larger zoecia.

Position and locality: Upper beds of the Cincinnati group at Wilmington, Ill.

## MITOCLEMA? MUNDULUM, n. sp.

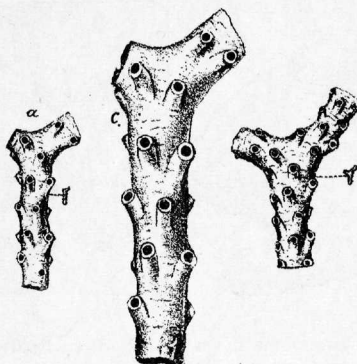


FIG. 4.—*Mitoclema? mundulum*, n. sp. *a* and *b*, two bifurcating fragments of this species, natural size, and *x9*. *c*, one of them *x18*.

Zoarium ramose, very small, the branches 0.5 or 0.6 mm. in diameter, with faint transverse striæ or wrinkles over the spaces between the zoœcia. The latter are tubular, with their apertures projecting strongly upward and outward, and not appreciably constricted. Diameter of protruding portion of zoœcium about 0.15 mm.

The interior of this species has not yet been determined because of the absence of specimens suitable for slicing. The generic position is therefore somewhat questionable, since it may prove to have the structure of *Diploclema*, Ulr., a genus including, externally, very similar forms.

Position and locality: Top of Trenton Shales, at Cannon Falls, Minn.

## DIASTOPORINA, n. gen.

Zoarium bifoliate flabellate, resembling *Diastopora*. Zoœcia tubular, prostrate, not entirely immersed. Apertures constricted oblique, the anterior side not elevated. Interpaces striated. Type, *D. flabellata*, n. sp.

## DIASTOPORINA FLABELLATA, n. sp.

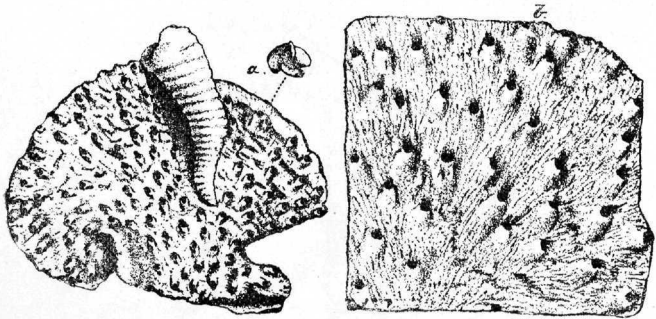


FIG. 5.—*Diastoporina flabellata*, n. sp. a, a complete zoarium of this species of the natural size and magnified seven diameters, showing arrangement of zoecia, fine interstitial striae and obscure concentric wrinkles. A small tubicolous annelid is attached to the frond. b, portion of same x18, to show the characters of the species more clearly.

Zoarium flabellate, small, bifoliate, very thin, 5.5 mm. wide. Surface with obscure concentric wrinkles, and finely striated parallel with the direction of the zoecia. Zoecia rather scattering, partly exposed, appearing as convex oval spaces with a small oblique aperture, 0.05 mm. in diameter, at the distal extremity. Small, non-celluliferous spaces occasionally. Under a high power of magnification, the fine striae which cover the interpaces appear as fine lines separating rows of exceedingly minute pores.

This species is regarded as a Cyclostomatous bryozoan with relations to *Diastopora* and *Berenicea*.

Position and locality: Rare at the top of the Trenton Shales, near Cannon Falls, Minn., where it is associated with *Arthroclema armatum*, *Helopora mucronata*, *Nematopora granosa* and other minute Bryozoa described in this paper. The horizon is a very interesting one.

## PHYLLOPORINA SUBLAXA, n. sp.

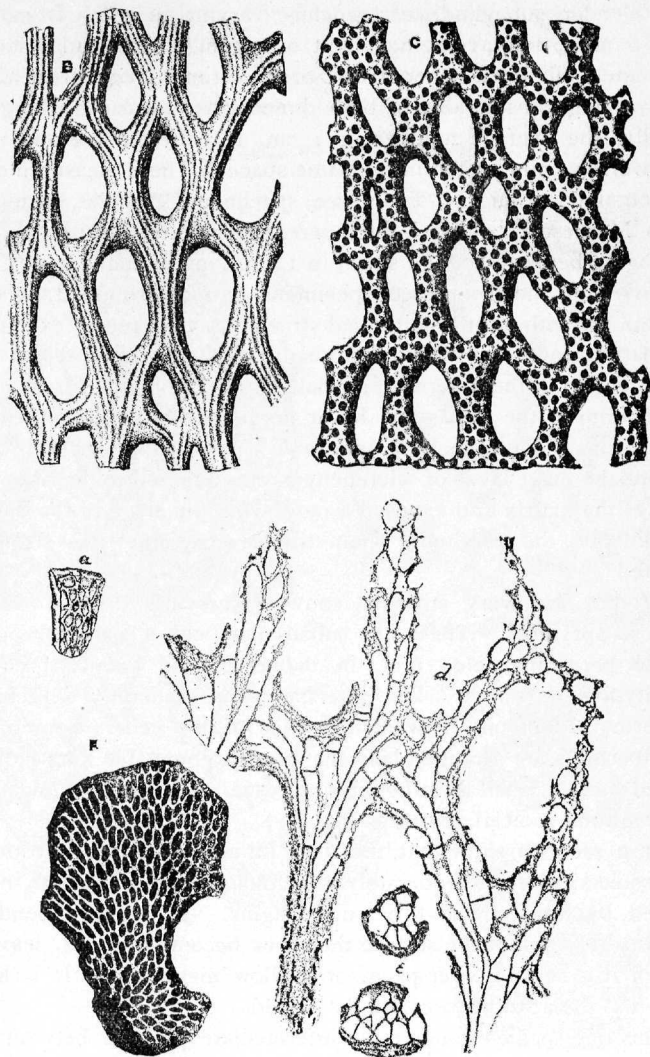


FIG 6—*Phylloporina sublaxa*, n. sp. a, fragment of this species. b, portion of same, x9, showing strongly striated character of the reverse in young or exfoliated examples. c, obverse side of another specimen, x9. d, tangential section, x18, showing appearance of zoecia at varying depths. e, two transverse sections of branches, x18. f, a rather loosely woven example from Tennessee, natural size.

Zoarium an undulating flabelliform expansion, attaining a diameter of 5 cm. or more, consisting of irregularly inosculating slender subcylindrical branches, varying in width from 0.3 to 0.6 mm., but averaging about 0.45 mm. Fenestrules large, subacutely elliptical, generally two or three times longer than wide, but varying considerably in both dimensions; measuring longitudinally, the average number in 1 cm. is between five and six; transversely, nine or ten in the same space. These measurements are obtained from the Tennessee specimens. In the examples from Minnesota, which I refer here, the fenestrules are smaller, averaging between six and seven in 1 cm. longitudinally.

*Reverse* of the Tennessee specimens strongly rounded, nearly smooth, or with faint longitudinal striæ. In very young examples the latter would probably be more distinct. Fig. *b* represents an enlargement of the reverse of a small fragment obtained from near the bottom of the Mississippi River gorge, at Minneapolis, Minn., by splitting open a block of limestone. As usual under such conditions the outer layer of sclerenchyma has adhered to the opposite side of the matrix and exposed a more youthful stage in the development of the zoarium, when the reverse side was strongly striated.

*Obverse* face very strongly convex, carrying three rows of zoecial apertures. These are subcircular, with a scarcely appreciable peristome, 0.09 mm. in diameter, and twenty-three to twenty-five in 5 mm. The interspaces are generally depressed, or form distinct pits between the ends of the cells. Sometimes the apertures are arranged between faintly appreciable longitudinal raised lines. Small acanthopores are usually scattered abundantly between the zoecial apertures.

Thin sections show that the long tubular primitive portion of the zoecia, which is moderately long and prismatic, is often intersected by from one to three diaphragms. Just before bending outward to open at the surface the tubes become rounded, leaving irregularly shaped interspaces or shallow mesopores. It is here also that the acanthopores are developed.

This fine species stands in an intermediate position between *P. trentonensis*, Nicholson, sp., and *P. granistriata*, Ul. The first is more robust, has the rows of cells more numerous and the axial portion of the zoecia much longer. The second has more rigid branches, longer and narrower fenestrules, and the reverse of the



branches granistriate and more delicate. *P. reticulata*, Hall, sp., is a much more delicate species.

Position and locality: The Tennessee specimens are from lower Trenton limestones (Glade) at Lebanon and La Vergne. The Minnesota ones were collected from the limestones a few feet above the St. Peter's sandstone, near Minneapolis.

PHYLLOPORINA HALLI, n. sp.

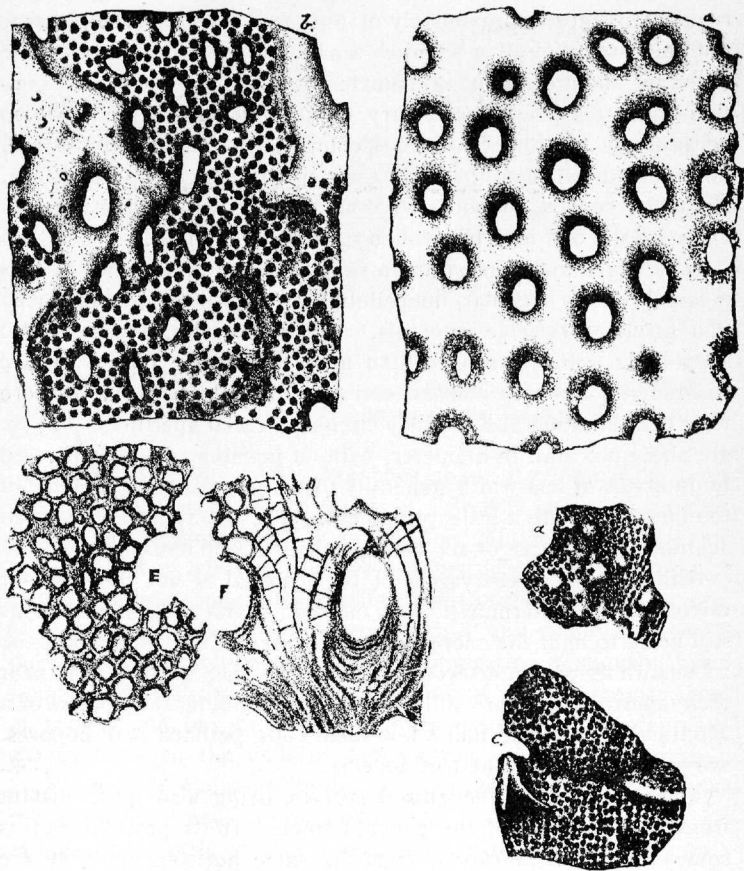


FIG. 7.—*Phylloporina Halli*, n. sp. *a*, poriferous side of specimen, natural size, showing the irregular, solid swellings. *b*, part of same x9. *c*, reverse side of another example, natural size; *d*, portion of same x9. *e*, tangential section X18, cutting the zooecia just beneath their mouths; *f*, another portion of the same section where it divides the zoarium at a deeper level.

Zoarium an undulating foliate expansion, of unknown dimensions; the largest fragment seen is 3.5 cm. in diameter; thickness of strongest varying between 1.5 and 2.0 mm. Branches scarcely distinguishable as such, the zoarium having the appearance of a perforated plate rather than consisting of inosculating branches.

*Reverse* with the fenestrules small, subcircular or oval, arranged more or less regularly in longitudinal and diagonal series, with from eight to ten in 1 cm. either way. When the arrangement is regular they are approximately of the same size, but when that is not the case some may be much smaller than the average. The latter are about 0.4 mm. in diameter. Over portions of old examples there may be a secondary deposit of sclerenchyma which occasionally fills the fenestrules completely. Such deposits are, however, much less frequent than upon the celluliferous face. Branches convex, smooth, with an average width of 0.65 mm. Occasionally one may be swollen to twice that width.

*Obverse* generally presenting a very irregular appearance. This is largely due to irregular, noncelluliferous deposits of sclerenchyma that occur at variable intervals. The fenestrules, however, also seem less regularly arranged than upon the reverse face. Surface of branches strongly convex, carrying from three to six or more rows of alternating and scarcely circular zoecial apertures. These are about 0.9 mm. in diameter, without peristomes, and separated by intervals of less width generally than their diameter. Some of the interspaces are a little prominent. These may have contained acanthopores. Five or six cell apertures in one mm.

Although the preservation of the material is not the best for microscopical determination of internal characters, thin sections still bring to light the more salient features. They show that the zoecial tubes are intersected by numerous diaphragms; that near their apertures they are still prismatic, resembling the zoecia of a Monticuliporoid, and that a few small cells, perhaps acanthopores, are scattered among the true zoecia.

This is an easily recognized species, being also quite distant from all the others of the genus known. In its proportions it is somewhat like *P. corticosa*, from the same horizon, but they are not likely to be confounded, the strong carinae on both sides of the branches in that species serving amply in distinguishing them.

The specific name is given in honor of Prof. C. W. Hall, of the State University of Minnesota, who is taking a lively interest

in the collection and determination of the Silurian fossils of Minnesota, and to whom I am indebted for many favors.

Position and locality; Upper part of the Trenton Shales, at St. Paul, Minn., where they were collected by the author.

RHINIDICTYA MINIMA, n. sp.

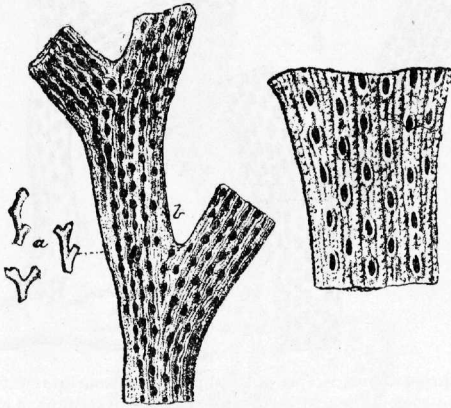


FIG. 8.—*Rhinidictya minima*, n. sp. *a*, three fragments of the natural size; *b*, one of them  $\times 9$ ; *c*, portion of same  $\times 18$ , to show narrow zoecial apertures and surface ornamentation more clearly.

Zoarium bifoliate, small; branches about 1.0 mm. wide, bifurcating at intervals of from 2 to 3 mm. Zoecia in five or six alternating longitudinal rows between the bifurcations where the branches have parallel margins. Apertures narrow, elliptical, small, 0.11 mm. long, about half as wide, with sixteen in 5 mm. longitudinally; margin of apertures thin and slightly elevated; interspaces unusually wide, sometimes appearing flexuously striate, usually with a distinct, granose, longitudinal line between the rows of zoecia and one or two short ones in the slightly depressed spaces between the ends of the zoecial apertures. Margin of branches acute, the noncelluliferous band rather wide and occupied by one or more lines of granules.

This pretty little species is easily recognized by its widely separated narrow zoecial apertures, and the granulo-striate character of the interspaces. Its branches also divide with unusual frequency.

Position and locality: Top of Trenton Shales, at Cannon Falls, Minn., where it is associated with numerous other small Bryozoa.

## RHINIDICTYA EXIGUA, n. sp.

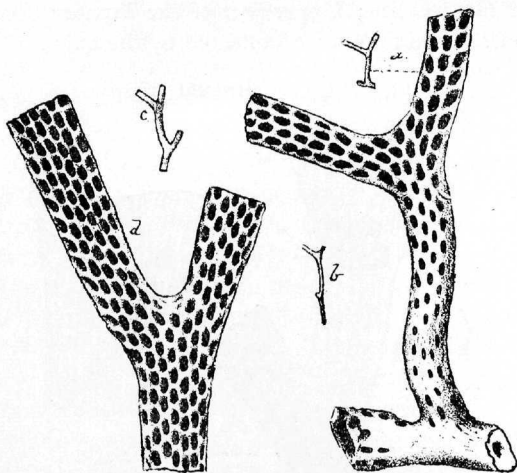


FIG. 9.—*Rhinidictya exigua*, n. sp. *a*, basal portion of zoarium, natural size and  $\times 9$ : near the base the zoecial apertures mostly closed by a secondary deposit; *b*, a very narrow specimen with only three rows of cell apertures; *c*, a wide example, having five and six rows; *d*, lower portion of same  $\times 9$ .

Zoarium bifoliate, small; branches, except near the base, thin and very slender, their width varying between 0.5 and 1.0 mm.; bifurcating at intervals of 5 or 6 mm. Basal portion of zoarium subcylindrical, and with the zoecial apertures largely filled with a smooth, solid deposit of sclerenchyma. The branches, however, soon become flattened and sharp-edged, but at no time is there more than just an appreciable noncelluliferous border. Above the first bifurcation the branches are acutely elliptical in cross section, and exhibit from three to six rows of zoecia on each face. The apertures of the zoecia are impressed subelliptical or subquadrate, those in the central rows 0.2 mm. long by 0.1 mm. wide, those in the marginal rows oblique and often a little larger, all regularly arranged longitudinally, seventeen or eighteen in 5 mm. Interspaces very thin, about equal at the sides and ends of the zoecial apertures, smooth (without granules) so far as observed.

The characters relied upon in distinguishing this species are its narrow branches, thin interspaces, small zoecia and comparatively large apertures. It is closely related to *R. paupera* (*Stictopora*

*paupera*, Ulrich) occupying a higher horizon in the shales. *R. mutabilis*, Ulr., a much larger species, is associated.\*

Position and locality: Lower beds of the Trenton Shales at Minneapolis, Minn., and vicinity.

RHINIDICTYA HUMILIS, n. sp.

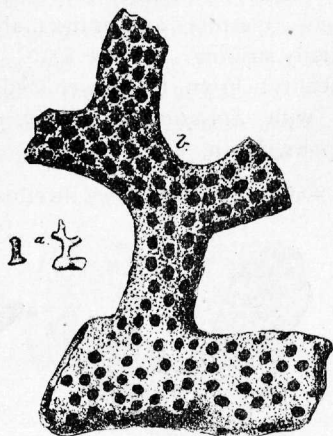


FIG. 10.—*Rhinidictya humilis*, n. sp. *a*, two specimens of the natural size, both preserving the basal portion. *b*, the largest x9, showing the arrangement of the zoecia, granulose interspaces, and frequent bifurcation of the zoarium.

Zoarium bifoliate, dwarfish; branches strongly convex, 1.0 mm. or a little less in width, arising from a strong basal expansion, and bifurcating at intervals of about 2 mm. Zoecia in from three to five ranges, their apertures impressed subcircular, 0.12 mm. in diameter, widely separated and irregularly arranged over the basal portion, but almost crowded near the distal extremities of the branches. The arrangement of the apertures is either in longitudinal rows or in quincunx. When the latter arrangement prevails, seven apertures may be counted in 2 mm., measuring along one of the oblique rows. Interspaces of variable width, more than equal to the diameter of the zoecial apertures on the basal expansion, but gradually becoming narrower upward till just beyond the first bifurcation, after which they are subequal and usually about half as wide as the zoecia mouths; carrying an abundance of

\*The Tennessee species, *Bythopora nashvillensis*, Miller, which is a bifoliate bryozoan and not a *Bythopora* at all, but belongs to *Rhinidictya*, is also related, but is distinguished by its more convex branches, smaller cell apertures and thicker interspaces.

small papillae. Nonporiferous margins granulose, obsolete above the first bifurcation.

The dwarfish appearance of this species distinguishes it from *R. nicholsoni*, Ulr. That species has much wider branches bifurcating at very long intervals. The growth is like in *R. minima*, but the two species are quite different in other respects, the differences in the size of the zoëcia apertures and in the markings of the interspaces being especially striking.

Position and locality: From the lower beds of the Trenton Shales, associated with *Stictoporella frondifera* and *Pachydictya foliata*, at Minneapolis, Minn.

PACHYDICTYA PUMILA, n. sp.

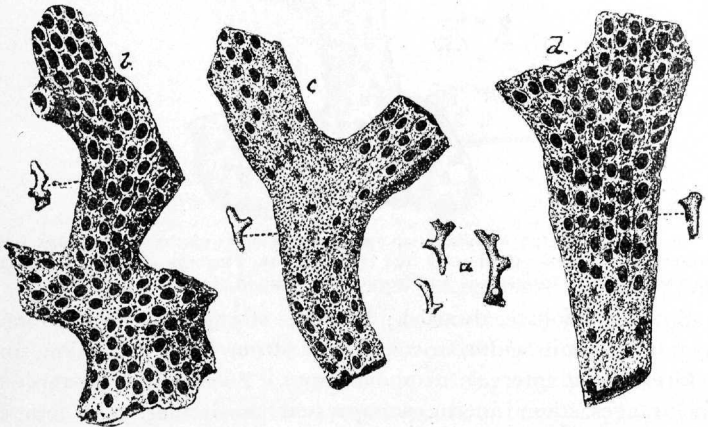


FIG. 11—*Pachydictya pumila*, n. sp. *a*, three specimens of the natural size. *b*, a small specimen preserving the base, natural size, and  $\times 9$ . In this specimen the surface is well preserved and all the zoëcial apertures open. *c* and *d*, two fragments, natural size, and  $\times 9$ , with many of the apertures closed by a granulose secondary deposit.

Zoarium bifoliolate, small; branches from 1.0 to 1.5 mm. wide, bifurcating at frequent intervals. Zoëcia in from four to six longitudinal rows, with about seven in 2 mm. Apertures elliptical, averaging about 0.15 mm in length, and 0.1 mm. in width, enclosed by a very thin peristome. Interspaces slightly depressed or flat, and, like the moderate non-celluliferous margins, filled with small papillae. It happens frequently that these papillae extend over large patches of the surface where the zoëcial apertures have been closed by a thin deposit of calcareous material. In very young examples, or at the distal extremities of the branches

of more mature ones, the longitudinal interspaces between the zoöcial apertures may show one or two pits or vesicles.

Internal structure in conformity with that required by the genus.

*Pachydictya triserialis*, the next described, is the only other very small species of the genus known to me. These two can not be confounded. *P. acuta*, Hall, is larger in every respect. None of the other species are closely related. It is associated with *Rhindiactya minima*, Ulr., but as soon as the differences have been grasped they will be distinguished at once.

Position and locality: Top of Trenton Shales, at Cannon Falls, Minn., associated with numerous other small Bryozoa.

PACHYDICTYA TRISERIALIS, n. sp.

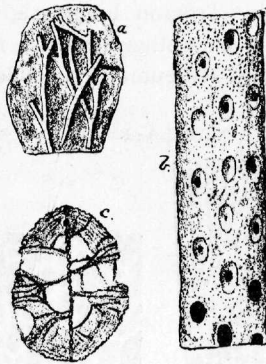


FIG. 12.—*Pachydictya triserialis*, n. sp. *a*, small portion of a piece of Trenton limestone showing several of a group of branches of this species, all belonging to a single zoarium. *b*, portion of one of the branches  $\times 18$ , showing the arrangement of the three rows of zoöcia and the minutely granulo-striate character of the interspaces. Most of the zoöcial apertures are closed by perforated or entire opercula-like structures. *c*, transverse section of a branch  $\times 25$ , showing the median tubuli along the divisional central line.

Zoarium, consisting of very slender, parallel-margined and but little compressed branches, bifurcating at intervals of from 5 to 10 or more mm. Branches oval, or obtusely hexagonal in cross-section, the margins never being acute, and at the most may sometimes be described as narrowly rounded. Each face with three rows of longitudinally-arranged zoöcial apertures. The latter are elliptical, about 0.2 mm. long and 0.1 mm. wide, surrounded by a scarcely appreciable peristome, and often preserve centrally perforated covers; the interspaces between the ends of the apertures are longer than usual, and only eleven apertures

occur in 5 mm. measuring longitudinally. Interspaces occasionally subangular between the rows of zoecia; everywhere exhibiting a very fine granulo-striate character. Non-periferous margins inconspicuous, generally wider on one side than on the other.

The subhexagonal narrow branches of this species present considerable resemblance to species of *Nematopora* like *N. lineata* (*Helopora lineata*, Billings). Of course, there is no real affinity between them, this being, as is clearly shown by transverse sections, a bifoliate zoarium, while in *Nematopora* the zoecia diverge equally in all directions from the center of the branch. I am not acquainted with any species of *Pachydictya*, nor with any associated species of bryozoan, with which the slender ramulets of *P. triserialis* might be confounded.

Position and locality: Trenton limestone, Montreal, Canada. The specimens, together with other Bryozoa, received in exchange from the Peter Redpath Museum, were collected by Mr. T. C. Curry.

STICTOPORELLA RIGIDA, n. sp.



FIG. 13.—*Stictoporella rigida*, n. sp. *a*, a bifurcating branch of this species, natural size, and part of same x9. *b*, portion of same x18, showing the arrangement of the zoecia apertures, interstitial pits or mesopores, and character of margins.

Zoarium a narrow branching, bifoliar stipe. Branches flattened, 1.0 mm. or a little more wide, with straight parallel and sharp margins, acutely elliptical in cross-section. Zoecia in seven to nine or ten rows on each face, their apertures arranged in very regular longitudinal and diagonally intersecting series, with six-



teen or seventeen in 5 mm. lengthwise and four in 1 mm. obliquely. Apertures elliptical, 0.2 mm. long, half that wide, impressed, the sloping area narrow for this genus, and appearing sometimes a little oblique because of a slight elevation of the posterior border; those in the marginal rows are directed slightly outward. Between the ends of succeeding zoecial apertures one or two small mesopores. There is usually a row of these small pores along the border of the branches. Interspaces narrowly rounded or ridge-shaped, comparatively thin.

This is a handsome and easily recognized species, *S. interstincta*, Ulr., from the Utica horizon of the Cincinnati group, and the only species of the genus with which it need be compared, has more numerous mesopores, wider branches, and much wider sloping areas about the smaller zoecial apertures. I have described three other species of this genus from the Trenton Shales of Minnesota, and there is yet another that remains undescribed. *S. angularis* has wider branches, has numerous mesopores and much thicker ridge-shaped interspaces between the zoecial apertures. *S. frondifera* grows into broad fronds and has zoecia like those of *S. angularis*. *S. cribrosa* forms cribose zoaria resembling those of *Clathropora*.

Position and locality: Rare in the Trenton Shales at Fountain, Minn.

ARTHROSTYLUS CONJUNCTUS, n. sp.

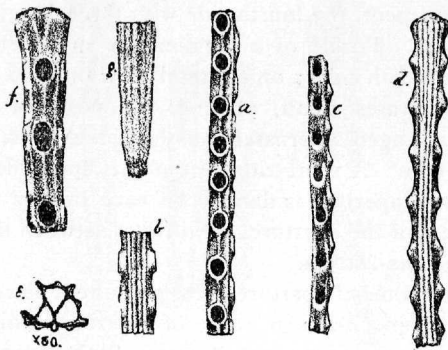


FIG. 14.—*Arthrostylus conjunctus*, n. sp., and *A. obliquus*, n. sp. a, lateral view of central portion of segment of *A. conjunctus* x18. b, view of portion of non-celluliferous side of same. c, lateral view of central portion of segment of *A. obliquus*, x18. d, non-celluliferous side of same, showing about three-fourths of the segment with the upper extremity, x18. e, transverse section of *Arthrostylus tenuis*, James, sp., x50. f, obverse side of upper end of segment of same, magnified twenty-eight diameters.

Zoarium jointed; segments very slender, straight, needle-shaped, 3 or 4 mm. long, quadrangular in cross section, 0.25 mm. wide, 0.18 mm. thick, with zoecial openings on three sides, the fourth being without them, but marked instead with four parallel longitudinal striæ. Zoecial apertures broad-oval, direct, 0.11 mm. long, 0.09 mm. wide, enclosed by a sharply marked peristome. Peristomes of each row of apertures joined together by a thin ridge, having a length about equal to the larger or outer diameter of the peristomes. Eight zoecial apertures in each row in 2.5 mm. A thin ridge, on each side of the range of apertures of the obverse face of the segment, separates it from the lateral rows. Apertures usually arranged alternately in the three rows.

This species is closely related to *A. tenuis*, James, sp., but is distinguished by having the non-celluliferous side narrower and with fewer striæ, causing transverse sections to be more nearly square. The *A. obliquus* differs in having oblique zoecial apertures.

Position and locality: Base of Trenton Shales, near Minneapolis, Minn.

ARTHROSTYLUS OBLIQUUS, n. sp. Fig 14, c, d.

Zoarium jointed, segments very slender, needle-shaped, straight or slightly curved, about 4 mm. long, subquadrangular in cross-section, 0.2 mm. wide, 0.15 mm. thick, slightly expanding toward the upper extremity. Zoecia in three rows occupying as many faces of the segment, the fourth side with three longitudinal striæ, and no zoecia. Profile of a segment on an obverse or reverse view, wavy on both sides; on a lateral view only on one side.

Zoecial apertures small, oblique, the posterior margin very prominent, arranged alternately in the three rows, with nine in each, in 2.5 mm. A short ridge from the upper depressed edge of each zoecial aperture is flanked on each side by the prolonged lateral borders of the aperture. No ridge between the lateral and central row of the zoecia.

The oblique zoecial apertures, the prominent lower border and absence of ridges between rows of apertures, distinguish this species from *A. conjunctus* and *A. tenuis*, both of which it resembles in other respects.

Position and locality: Trenton Shales, Minneapolis, Minn. Rare.

## HELOPORA, Hall.

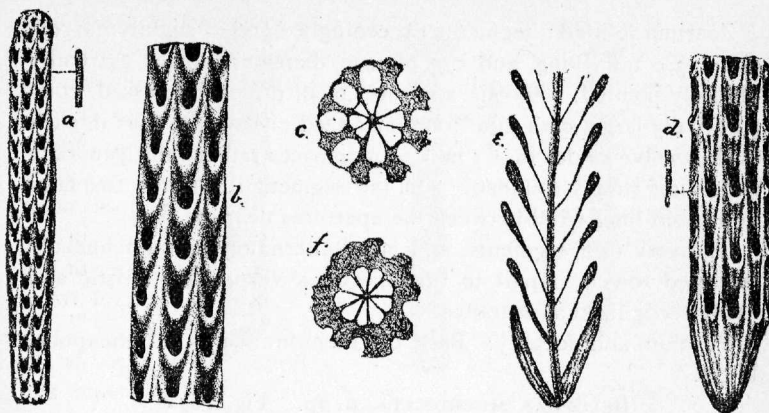


FIG. 15.—Illustrating species of *Helopora*. *a*, *b* and *c*, *H. divaricata*, Ulrich, Trenton Shales, Minneapolis, Minn. *a*, segment, natural size, and  $\times 7$ . *b*, portion of same  $\times 18$ . *c*, transverse section  $\times 18$ . *d*, *e* and *f*, *H. spiniformis*, Ulrich, Birdseye limestone, Lebanon, Tenn. *d*, a segment of the natural size, and its lower half  $\times 18$ . *e*, vertical section of lower half. *f*, transverse section  $\times 18$ .

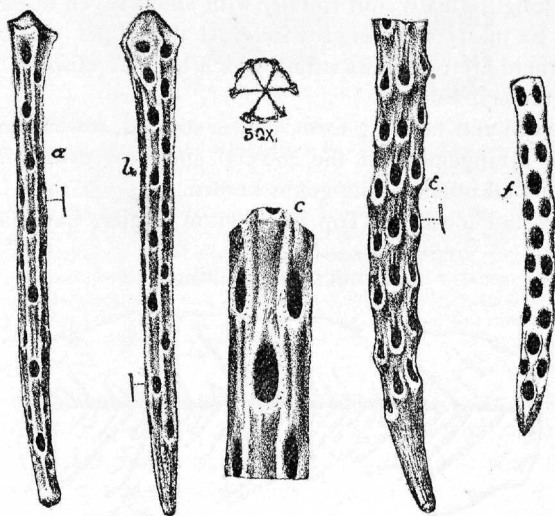


FIG. 16.—Illustrating species of *Helopora*. *a* and *b*, two complete segments of *H. harrisi*, James,  $\times 18$ , from the upper beds of the Cincinnati group, at Waynesville, O. *c*, portion of one  $\times 50$ . *d*, transverse section of a segment  $\times 50$ , showing six rows of zoecia. *e*, a segment of *H. mucronata*, n. sp., and most of it magnified to eighteen diameters, showing its slight curve, tapering form, the arrangement of the zoecial apertures and striae above each. *f*, the lower and most of the upper half of a segment of *H. alternata*, n. sp.,  $\times 18$ .

## HELOPORA ALTERNATA, n. sp. Fig. 16, f.

Zoarium jointed; segments exceedingly slender, slightly curved, about 3.0 mm. long, and 0.5 mm. in diameter; lower extremity obtusely pointed. Zoecia apertures oval, direct, impressed, comparatively large, 0.14 mm. long, arranged alternately, four in each cycle, twelve cycles in 2.5 mm. Interspaces rather thin, generally appearing simply rounded. On the segment illustrated two faint impressed lines wind between the apertures near the base.

The very thin segments, and large alternately or quincuncially arranged zoecia impart to this species a very characteristic and easily recognized appearance.

Position and locality: Base of Trenton Shales, Minneapolis, Minn.

## HELOPERA MUCRONATA, n. sp. Fig. 16, e.

Zoarium jointed. Segments spine-like, slightly curved, 3.5 to 4.0 mm. long, tapering downward from a diameter of 0.6 or 0.7 mm. to the acute and finely striated basal extremity. Zoecia apertures oblique, the inferior and lateral margins elevated, arranged longitudinally and spirally with about seven in one revolution, and six in 2.5 mm. lengthwise. At the upper side of each aperture there are two short striae, which become obsolete as they pass into the cell mouth.

The curved and tapering form, acute, striated, lower extremity, and spiral arrangement of the zoecial apertures distinguish this species from all others of the genus known.

Position and locality: Top of Trenton Shales, Cannon Falls, Minn.

## ARTHROCLEMA, Billings.

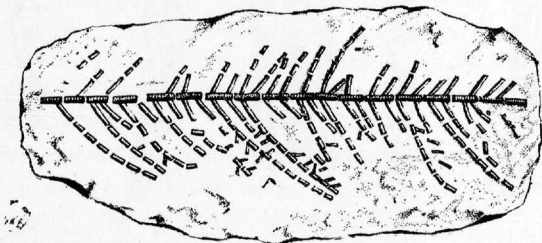


FIG. 17.—*Arthroclema Billingsi*, Ulrich. A nearly complete example of this species, from the Trenton limestone at Ottawa, Canada, introduced to illustrate the mode of growth prevailing in this genus. The species is described in Vol. VIII., Reports Geological Survey of Illinois, p. 642 (in press). (NOTE.—This figure is turned sideways to adjust it to the length of the page.—ED.)

## ARTHROCLEMA CORNUTUM, n. sp.

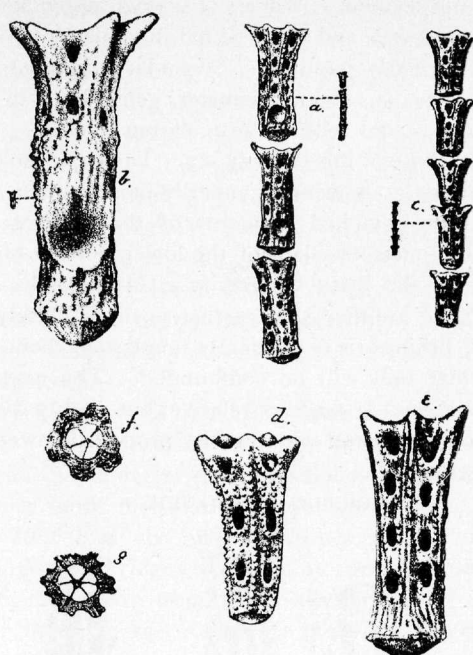


FIG. 18.—*Arthroclema cornutum*, n. sp. *a*, four of the primary segments in connection, with three  $\times 7$ , showing the articulating sockets near the base of each, and the usual appearance of the segments of this series; *b*, a very perfect primary segment, natural size and  $\times 18$ , showing unusually deep socket, and the irregular granulations of the surface; *c*, a series of six segments of the secondary order, and five of them  $\times 7$ ; the segments of this order are without articulating sockets, and may have either three or four cycles of zoecia; *d*, secondary segment with three cycles of zoecia  $\times 18$ , showing granose ornamentation and other characters; *e*, larger and differently marked secondary segment with four cycles of zoecia  $\times 18$ ; *f*, transverse section of secondary segment from near its upper extremity, showing five rows of zoecia  $\times 18$ ; *g*, transverse section of primary segment, from near its lower extremity, showing six rows of zoecia  $\times 18$ .

Zoarium jointed, the segments consisting, so far as known, of only a primary and a secondary series. Primary segments, six-sided, about 2.2 mm. long, and 0.7 mm. in diameter, with the six angles, more or less sharply defined and produced at the truncated upper extremity into as many horn-like projections. Near the lower extremity, which is often a little bulbous and radially striated, usually two subcircular articulating sockets, placed one on each of two opposite faces of the segment. Zoecia generally in four, rarely in five cycles, the apertures of those of the uppermost

cycle more oblique than the others, and situated very near the upper extremity of the segment. Angles of segments, peristomes of the oval zoöcial apertures, and longitudinal interspaces between them, more or less regularly papillose. Secondary segments 1.5 to 1.8 mm. long, about 0.45 mm. in diameter, generally with only three cycles of zoöcia, and without articulating sockets. Otherwise very similar to those of the primary set. The papillose ornamentation of the surface is, however, generally more regular.

The neat little detached segments of this species are rather plentiful on the limestone slabs of the lower portion of the Trenton Shales, near the State University at Minneapolis, Minn. A larger segment of another species that is more closely related to *A. pulchellum*, Billings, is occasionally found with them. It is not at all likely that they will be confounded. The next described species (*A. armatum*) is a nearer relative, but readily distinguished by its larger segments and prominently produced lower border of its zoöcial apertures.

ARTHROCLEMA ARMATUM, n. sp.

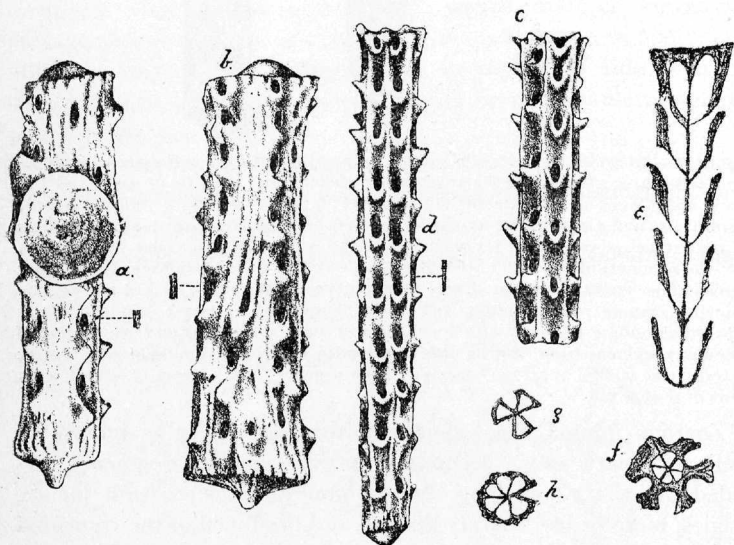


FIG. 19.—*Arthroclema armatum*, n. sp. *a*, large segment of the primary series, showing a sharply defined articulating socket. *b*, opposite side of another segment of the primary set. *c*, a broken segment of the secondary series, the upper half being preserved. *d*, another, but entire, segment of the secondary set. *e*, vertical section of a secondary segment, showing central axis and form of zoöcia. *f*, transverse section of primary segment. *g* and *h*, two transverse sections of secondary segments, one with six the other with seven rows of zoöcia. All the figures are magnified eighteen diameters.

Zoarium jointed, so far as known consisting of primary and secondary segments only. Primary segments, from 3 to 5 mm. long, 0.5 to 1.0 mm. in diameter, the thickest generally the longest, and always with a well-marked socket for articulation with the first of the secondary segments. Only one socket on any segment, and some of them are without any. The socket is situated generally a little above the center of the length. Some of the joints of this set are decidedly compressed or irregularly shaped, and all more or less distinctly striated longitudinally. Both ends truncate, but with the central portion of the upper convex, and the lower more acutely drawn out. Zoœcia usually in six ranges, their apertures oval, nearly direct, 0.1 mm. long, with about seven in each range in 2.5 mm.; a strong tubercle just behind or near each aperture.

Secondary segments of about the same length as those of the primary set. They are, however, more slender, none being more than 1.5 mm. in diameter, and the smallest ones only about 0.3 mm. Upper end terminating abruptly, spinous, lower end rounded. Zoœcia is six and sometimes seven, rows arranged between longitudinal ridges that become stronger with age; a transverse arrangement also usually prevails; apertures oblique, with the inferior border very prominent, spine-like, seven in 2.5 mm.

Mature and well-preserved segments of this species could not well be confounded with any other jointed bryozoan known to me. Immature joints of the secondary series must be examined with some care, to separate them from the segments of the associated *Helopora mucronata*. In that species the segment enlarges gradually from the pointed inferior end, the zoœcial apertures are not arranged between longitudinal ridges, and above each aperture there are two thin striæ, which are wanting in this species. The spine-like prominence of the inferior margin of the zoœcial apertures serves sufficiently in distinguishing *A. armatum* from the other species of the genus.

Position and locality: Top of the Trenton Shales, at Cannon Falls, Minn., where it is associated with numerous other small bryozoa.

## NEMATOPORA GRANOSA, n. sp.

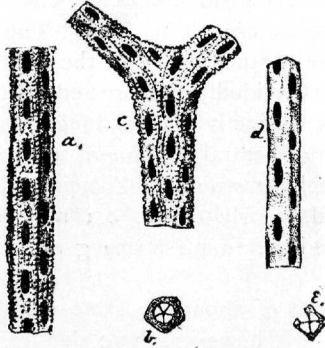


FIG. 20.—*Nematopora granosa*, n. sp. *a*, unbranched fragment  $\times 18$ , with five rows of zoecia, showing the granulose angles and interspaces, and narrow zoecial apertures. *b*, end view of same. *c*, bifurcating fragment  $\times 18$ , with the rows of granules slightly flexuous. *d*, slightly worn fragment with only four rows of zoecia. *e*, end view of same.

Zoarium ramose; branches bifurcating at rather long intervals, from 0.25 to 0.38 mm. in diameter, the smallest quadrangular in cross-section and with only four rows of zoecia; those of the average size, pentagonal, and with five rows of cells. Zoecial apertures small, narrow, about seven in each range in 2.5 mm., enclosed by a series of minute granules. Longitudinal interspaces with a small number of similar granules. Rows of apertures separated by more or less well-developed straight or slightly flexuous granulose ridges.

The papillose ornamentation and narrow zoecial apertures of this species distinguish it from all the others known to me. There is considerable external resemblance to small species of *Rhombopora* like *R. lineinodis*, Ulr., and *R. regularis* (*Trematopora regularis* and *Orthopora regularis*, Hall), but not much in the more important internal characters.

Position and locality: Top of Trenton Shales, Cannon Falls, Minn.



## NEMATOPORA OVALIS, n. sp.

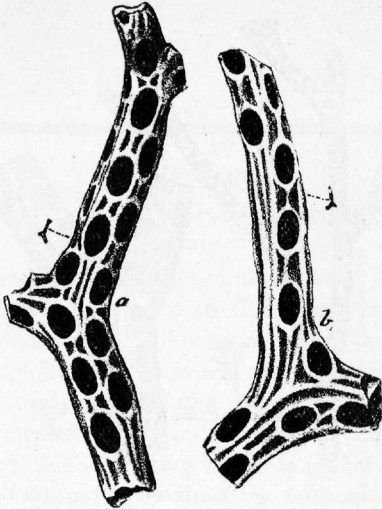


FIG. 21.—*Nematopora ovalis*, n. sp. *a*, fragment of the natural size and x18, with five ranges of zoecia. *b*, another with more ridges, only four rows of zoecia, and the apertures less closely arranged.

Zoarium ramose; branches bifurcating at intervals of about 2 mm., 0.3 to 0.4 mm. in diameter, subquadrangular or pentagonal in cross-section, each face with a row of zoecia. Zoecial apertures direct, very large, oval, nearly 0.3 mm. long by 0.15 mm. wide, enclosed by a sharply defined peristome. A short ridge joins the peristomes of each row of apertures, and longitudinally divides the concave spaces between the ends of the apertures. These spaces are larger in the subquadrate examples than in those having five rows of zoecia. They also have the thin ridge that bounds each face more distinct from the elevated margins or peristomes of the zoecial apertures, which, in the pentagonal specimens, to a large extent also form the border of the faces. Longitudinal interspaces generally shorter than the length of the zoecial apertures; about five of the latter in 2.5 mm.

The large zoecial apertures serve to distinguish this species from all the others known to belong to the genus. Under the microscope the general appearance of the zoarium is strikingly different from that of *N. granosa*, with which it is associated.

Position and locality: Top of Trenton Shales, Cannon Falls, Minn.

## NEMATOPORA CONFERTA, n. sp.

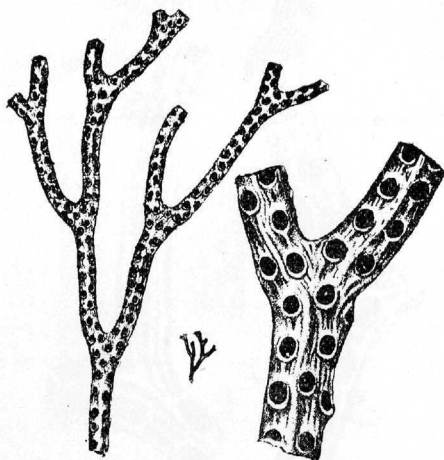


FIG. 22.—*Nematopora conferta*, n. sp. Zoarium of this species, natural size, x9, and portion of same magnified eighteen diameters.

Zoarium ramose; branches dividing dichotomously at intervals of about 2 mm., 0.4 to 0.5 mm. in diameter, subcircular in cross-section. Zoecia in five or six longitudinal ranges, their apertures subcircular or broad-oval, frequently arranged also in rows encircling the stems; slightly oblique, surrounded by a thin peristome, strongest and most elevated posteriorly; diameter of apertures 0.15 mm., separated by intervals, longitudinally, greater than the diameter, between seven and eight in 2.5 mm. Interspaces striated, occasionally rising into ridges which separate the longitudinal ranges of zoecial apertures for a short distance.

The smaller, subcircular apertures and simply striated interspaces distinguish this species from *N. ovalis*. *N. alternata*, Ulr., from the Galena or Upper Trenton of Southern Illinois, has the zoecial apertures arranged in quincunx. In *N. retrorsa*, from the same locality and formation, they are ranged between longitudinal ridges.

Position and locality: Top of Trenton Shales, Cannon Falls, Minn.