LOWER SILURIAN BRYOZOA.

E. O. ULRICH.

[EXTRACTED FROM VOL. III OF THE FINAL REPORT OF THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.]

CHAPTER IV.

ON LOWER SILURIAN BRYOZOA OF MINNESOTA.

BY E. O. ULRICH.

INTRODUCTORY REMARKS.

To the Bryozoa must be accorded the first rank among the various classes of fossils that are represented in the Lower Silurian rocks of Minnesota. They are entitled to this distinction, first, because of the great variety of form and structure found among them, and, second, because of their exceeding abundance, in the way of individuals. In both of these respects their representation exceeds that of the Brachiôpoda, which doubtlessly held the second rank, in the approximate ratio of two to one. So plentiful are their remains in some of the beds, particularly in the shaly members, that they may be said to constitute no inconsiderable part of the strata. In the Trenton shales the intercalated plates of limestone are literally covered with them, and they are not rare even in the massive limestones above and beneath the shales, which were deposited under conditions much less favorable to their development. In short, of every impartial collection of the Lower Silurian fossils of Minnesota, the Bryozoa necessarily constitute a large portion, not only of the number of species and specimens, but of its bulk as well.

The importance of the Bryozoa from the view of the stratigraphical geologist, is again second to no other class of fossil remains. Many of them have a wide geographical distribution, and as they usually occur in greater or less abundance, and are very persistent in their characters, their value as data upon which to base correlations of strata at widely separated localities cannot be overestimated. Many of them, especially of the suborder *Trepostomata*, are serviceable even where other fossils are too imperfect, since with the aid of thin sections mere fragments can often be identified with certainty.

Living Bryozoa are all inhabitants of water, and mainly of the sea, occurring in all zones and at varying depths, though seeming in general to prefer clear and shallow water. With the single exception of the genus *Loxosoma*, they are composite animals, which by the combined efforts of the individual polypides built up colonies of greater or less extent, and of either a calcareous, corneous, or membranaceous composition, by means of repeated, continuous gemmation. These colonies, in both the living and fossil forms, present so great a variety of form and habit, that it is difficult if not impossible, to express their growth by any definite formula. Sometimes they grow in plant-like tufts, composed of series of cells variously linked together; sometimes they spread over shells and other foreign bodies, forming entire crusts of exquisite pattern, or delicately interwoven threads; sometimes they rose into coral-like masses, branching stems, and narrow or broad fronds; at other times the cell-bearing branches formed most beautiful and regular open-meshed lacework.

However diverse the external aspect of the combined product, the small builders themselves conform to a simple and quite definite type. Considered briefly, the polypide consists of an alimentary canal in which three distinct regions, an œsophagus, stomach, and intestine, are recognizable. This is enclosed in a sac, and bent upon itself so that its two extremities or openings approximate, one of them, the oral, being furnished with a number of slender, hollow, and ciliated tentacles, whose movement causes the food to be brought to the mouth. As a rule, the anal opening is situated without the ring of the tentacles. Generally the upper surface of the sac is flexible and capable of being invaginated by the action of retractor muscles attached to the alimentary canal, so that when the animal retreats into its cell the inverted portion forms a sheath around the tentacles. Heart and vascular system are wanting, but a nervous ganglion is present, and reproductive organs are developed in various positions within the cavity of the cell. The ova may be developed in a special receptacle (*marsupium*) attached to the zoœcium, or in an inflation of the surface of the zoarium, sometimes called a *gonocyst;* in other cases a modified zoœcium (*gonœcium*) is set apart for reproductive functions. The general term *oœcium* is applicable to all these structures. Many Bryozoa are provided with appendicular organs called avicularia and vibracula. The avicularia may be pedunculate, and sway to and fro, or they may be immovably attached to the zoœcium. The vibracula are flexible, bristle-like appendages, set in the excavated summit of a knob-like elevation or blunt spine. The acanthopores found so frequently among paleozoic Bryozoa, were probably the supports of similar structures.

TERMINOLOGY.

ZOARIUM (=*polyzoarium* and *cœnœcium* auctt.):—The composite structure formed by repeated gemmation.

ZOŒCIUM (=*cell* auctt.):—The true cell or chamber in which the polypide is lodged.

MESOPORES (=*interstitial cells* auctt.):—The angular or irregular cells which occupy the spaces between the zoœcia in many of the *Trepostomata* and some of the *Cryptostomata*,

VESICULAR TISSUE:—The vesicles which occupy the space between the zoœcia in *Pachydictya*, the *Fistuliporidæ* and other paleozoic Bryozoa.

ACANTHOPORES (=*spiniform corallites* Nicholson, *spiniform tubuli* Ulrich, *Wandrohrchen* Dybowski):—The tubular spines which are found in so many paleozoic Bryozoa, notably *Dekayia*, *Leioclema* and *Batostoma*.

MEDIAN TUBULI (*Wandstränge* Dybowski):—Very slender tubes which are present between the zoœcial walls and the median laminæ of certain double leaved forms (*e. g. Rhinidictyonidæ*). Their apertures at the surface are slightly elevated and present the appearance of series of minute granules. The small granules in *Rhombopora*, *Stenopora* and other genera, are supposed to be of the same character.

COMMUNICATION PORES:—Small pores which pass through the walls of the zoœcia and establish communication between adjacent cells.

OŒCIUM (=*ovicell, gonocyst, gonœcium* auctt.):—A modified zoœcium set apart for reproductive functions, the inflation of the zoarium in which the embryos are developed, or a special receptacle (marsupium) which is attached to the zoœcium, and serves the same purpose.

DIAPHRAGMS (=*tabulæ* and *septa* auctt.):—The straight plates which cross the tubular zoœcia and mesopores in the *Trepostomata* and a few forms of the *Cryptostomata*.

CYSTIPHRAGMS:—The convex plates which line the walls of the zoœcial tubes in some of the *Trepostomata* (*Prasopora*).

ZOŒCIAL COVERS (*opercula*) and PERFORATED DIAPHRAGMS:—Horizontal plates perforated subcentrally, covering the zoœcia in the *Trepostomata*. As growth proceeds in the colony these are left behind in the tubes, and mark the successive stages.

HEMISEPTA:—The superior hemiseptum is a plate or laminar projection within the posterior border of the primitive zoœcial aperture, common in the typical *Cryptostomata*. The inferior hemiseptum is a similar projection on the anterior wall, or on the median laminæ of bifoliate forms, situated a short distance beneath the superior hemiseptum. One or the other, or both may be absent.

LUNARIUM:—A more or less thickened portion of the posterior wall in many paleozoic Bryozoa, which is curved to a shorter radius and usually projects above the plane of the zoœcial aperture. It is of crescentic form, and generally a conspicuous feature in tangential sections.

PRIMARY APERTURE:—"The original orifice" of the zoœcium in the *Cryptostomata*.

SUPERFICIAL APERTURE:—The outer orifice of the tubular prolongation (vestibule) of the original aperture.

OBVERSE and REVERSE:—Two terms employed to designate, respectively, the celluliferous and non-celluliferous faces of the zoaria of the *Fenestellidæ*, *Acanthocladiidæ*, and *Phylloporinidæ*.

DISSEPIMENTS:—Short non-celluliferous bars connecting the cell bearing branches in the *Fenestellidæ*, at short and regular intervals. The rounded, hexagonal, or quadrate meshes of the network thus formed are known as the "fenestrules."

The following brief remarks upon the preservation, methods of study, classification, and geological distribution of fossil Bryozoa, the paleozoic forms of America in particular, may be of assistance to students. A more comprehensive general discussion of the subject is to be found in the introduction to my recent work in the eighth volume of the reports of the Geological Survey of Illinois.

PRESERVATION.

It is evident that the hard parts of the Bryozoa only could have been preserved in the fossil state. Equally obvious is the fact that these parts could consist only of the outer investment of the polypides. The opportunities of the paleontologist are restricted further to those in which this investment was calcareous, or corneo-calcareous. Judging from recent conditions, it would appear that of by far the greater part of the extinct forms, the colonies or zoaria were capable of preservation, since in a very large proportion of the living marine Bryozoa the skeleton is calcareous.

Certain changes in the composition and structure of the zoaria have always accompanied the process of fossilization. Indeed, it is probable that the mineral constituents of all fossils are never the same as they were in the living state. The least, and I am glad to state, the commonest alteration is where the originally amorphous calcite has been changed into the crystalline form of that mineral. In most cases this change has been so gradual, and the crystals formed so minutely, that very little of the structure has suffered obliteration. Very often many of the minutest details are still to be recognized. This favorable condition prevails among the majority of fossil Bryozoa, and is especially remarkable among those derived from Lower Silurian calcareous shales and limestones. When the shales are of a greenish color, as in parts of the middle third of the Minnesota Trenton shales at Minneapolis, and the shales of the Cincinnati group at Iron Ridge and Delafield in Wisconsin, the internal structure was generally completely destroyed through the coarseness of the crystallization. The same is true in a great measure of forms occurring in dolomitic limestones.

Silicified Bryozoa are comparatively of rare occurrence, especially in Lower and Upper Silurian rocks. In nearly all cases this method of preservation is confined to massive limestones, like the Corniferous and St. Louis, and in most cases it is unfavorable, so far as the minute internal structure is concerned. Still, in specimens so preserved, the external characters are often wonderfully perfect. Such specimens have been found at the Falls of the Ohio, where they occurred in the decomposed cherty limestones, from which they were washed free in as perfect a condition, so far as outer features are concerned, as when they were entombed. Silicified specimens may also be freed from the rock by means of dilute acids.

A rather common condition of preservation in Devonian and Carboniferous deposits, is where the calcareous zoaria have been dissolved away, leaving more or less perfect moulds in the matrix. This is usually a porous chert, like that frequently met with in the Corniferous limestone of New York and Canada, and the St. Louis limestone of Kentucky; or it is an arenaceous shale. This method of preservation is often very favorable, since, by pressing heated gutta percha into the empty moulds, it is possible to obtain very serviceable counterparts of the bryozoan that left them. Such casts, if carefully prepared, often bring out the most minute details of external marking with surprising fidelity. In the case of such delicate Bryozoa like the *Fenestellidæ*, these moulds are to be preferred to the usual preservation of calcareous specimens, the latter being too liable to attrition and decomposition.

METHODS OF STUDY.

The bulk of paleozoic Bryozoa, with which the American student is likely to be chiefly engaged, belong to the *Trepostomata* and *Cryptostomata*. In these the internal structure is of very diverse types, and it is impossible to arrive at a clear conception of them without the aid of thin sections. If possible, these should be prepared by the student himself, and even if he cannot command one of the new slicing machines, he may still obtain very excellent results by the simple home-made method which I am about to describe, and which served me in making thousands of sections.

The materials required are, (1) a piece of sandstone (not too gritty*) eight or ten inches wide, eighteen or twenty inches long, and of sufficient thickness to insure

*The Buena Vista freestone of the Ohio Waverly is the best known to me for the purpose.

solidity; (2) a piece of water hone one inch thick, a little wider, and four or five inches long; (3) a block of wood (walnut is the best) one inch thick, two inches wide, and four and one-half inches long. The edges of the upper side are rounded to fit the hand, while in the lower side a shallow excavation, one and one-sixteenth inches by three and one-eighth, is made to fit the ordinary glass slip. The excavation must be made so that the *central* portion of the glass slip will bear upon the block, while the ends may have a little play.

With a strong pair of "wire nippers" a fragment is pinched from the specimen of which sections are desired. This is taken into the fingers and rubbed upon the sandstone until the surface is perfectly flat. This is the most important part of the process, and the greatest care must be exercised to retain (or obtain, as the case may be) the desired angle. This surface is now rubbed smooth upon the hone, when the fragment is ready for mounting. A drop of Canada balsam is placed upon the glass slip, and the ground face of the fragment into it. The slip is now heated (on a heating stage or over a lamp) and the balsam allowed to boil for five or six seconds, when the slip is laid upon a horizontal piece of wood to cool. After it is cold the balsam should be tested, and, if it is not hard and brittle, must be reheated. If of the proper hardness, the block is moistened, the slip placed into the excavation, and the superfluous material rubbed away upon the sandstone. When nearly thin enough it is taken out of the block and finished upon the hone.

After thoroughly cleaning and drying, the section should be covered with a film of balsam and a thin sheet of glass. Air bubbles, if any are found, should be expelled by gently heating the slide and pressing upon the cover glass.

Of course it requires a certain amount of experience and time to make good sections, yet even the beginner ought to be able to make from twenty to thirty sections daily, while an expert may increase the number to forty and even fifty.

For reasons about to be mentioned, these sections must be prepared with a knowledge of certain peculiarities which are common to the Bryozoa, otherwise the sections will be misleading. Take for example any ramose or palmate form, and the student will find that the zoarium of such Bryozoa is composed primarily of two distinct zones, an inner or axial region where the zoœcia are tubular, more or less nearly vertical, and with very thin walls; and an outer or peripheral region composed of the same tubes bent outwards at varying angles in order to reach the surface. In this outer region the zoœcia are supposed to have entered the mature condition, and it is here only that such accessory features as the acanthopores and mesopores are developed.

The necessity of two sections, a vertical and a transverse, is at once obvious, but as neither of these sections will give us a cross section of the zoœcia in their peripheral region, where the adult and consequently the most important characters are to be found, it is evident that a third section must be prepared, which will enable us to investigate these characters. This section, which is called "tangential," must divide the zoarium along a plane parallel with the surface, and only a little below it.

Of bifoliate forms two tangential sections ought to be made, one passing through the zoarium just below the surface, and the other just above the median lamina. In thin examples of this style of growth one large section can be made to show the characters of the zoœcia from their origin to the aperture.

For massive, parasitic, or discoid zoaria, two sections (vertical and transverse) will ordinarily suffice to bring out the principal characters, but it is advised that two or more transverse sections be prepared, dividing the zoarium at different hights.

In beginning the study of Bryozoa the first essential is to learn to group them according to their outer form and mode of growth. The outward form, though extremely variable when the whole class is taken into consideration, is tolerably constant for each species, and not infrequently all the species of a genus will adhere more or less strictly to some particular method of growth. On the other hand many very distinct types may assume very nearly the same outward form. But the discrimination between these is a second step in the investigation.

The zoaria will usually exhibit one or the other of the following conditions:

1. The *parasitic* or *incrusting* zoarium, in which the colony is spread over foreign bodies. Examples, *Ceramoporella, Spatiopora, Stomatopora, Berenicea,* etc.

2. The *laminar* zoarium, is a thin, free expansion, having the lower side covered by a wrinkled epitheca. Examples, many species of *Fistulipora,* etc.

3. The *massive* zoarium, may be of irregular or rounded form, free, attached at the base, or grow around some foreign body. Examples, species of *Monotrypa* and *Monticulipora.*

4. The *discoid* zoarium has the form of a plano-convex, or concavo-convex disc; or it may be conical. The under side is concave or flat and covered with an epithecal crust. Examples, species of *Prasopora, Mesotrypa,* and *Leptotrypa discoidea* Nicholson.

5. The *bifoliate* zoarium, in which the zoœcia diverge from a double median lamina or basal plate, and open upon the two surfaces of a foliaceous expansion, or of flattened branches. Examples, all the *Rhinidictyonidæ* and *Ptilodictyonidæ.*

6. The *dendroid* or *ramose* zoarium, in which the entire free surface is celluliferous, is very common among paleozoic Bryozoa. Examples, *Batostomella, Bythopora, Hemiphragma, Nematopora.*

7. The *frondescent* or *palmate* zoarium is a modification of the ramose, differing from it in the flattening and expansion of the branches. Examples are *Heterotrypa frondosa* d'Orbigny and *Homotrypa flabellata* Ulrich.

8. The *jointed* zoarium, in which it is divisible into a greater or less number of subequal segments, that articulate with each other either terminally or by means of lateral sockets; is illustrated in *Helopora, Arthroclema* and *Arthropora.*

9. The *fenestrated* or *inosculating* zoarium, as in *Fenestella* and *Phylloporina.* The *pinnate* zoarium is a modification in which the parts of the fronds are feather-like in their arrangement. *Pinnatopora* and *Acanthocladia* are examples.

If the specimens under investigation fall under any except the last two modes of growth, they will probably exhibit either groups of cell-apertures larger than the average, commonly raised above the surface and therefore known as "monticules"; or clusters of small cells or smooth spots called "maculæ." The monticules may be rounded, low or conical, and sometimes ridge-like. Examples are shown on plate XXII, in figs. 1, 13 and 24. Frequently there is a combination of large and small cells as in figs. 18 and 19 of the same plate. True maculæ are best developed in the *Fistuliporidæ,* in which they consist of aggregations of lenticular vesicles, but on plate XVI, fig. 6, is a good example of the kind in which the cells are tubular. The non-poriferous margins, so common among the bifoliate Bryozoa, are most probably a modification of the maculæ; see plate VIII, fig. 19.

The presence or absence of interstitial cells between the ordinary zoœcia, and the determination of their character when present, is the third step in our investigation. These cells may be of the nature of "mesopores"—small, closely-tabulated tubes, as in *Prasopora* and *Callopora* (plates XVI, XXI, and XXII), or the interspaces may be occupied by "vesicular tissue" as shown in fig. 4 on plate IX, a vertical section of *Pachydictya frondosa.* The zoarium of *Monotrypa* is characterized by the complete absence of both mesopores and vesicles (see plate XXVII, figs. 24–29).

Important diagnostic characters are to be observed in the character of the mouths of the zoœcia. They may form short tubular projections (plate II, fig. 6), be enclosed by a smooth rim or peristome (plate I, figs. 17 and 28), or the rim may be minutely papillose (plate XIV, fig. 22); or the mouth may be depressed and situated in a sloping area (plate X, fig. 24). Other conditions, described by the terms "direct," "oblique," and "confluent," are obvious without the citation of examples.

Of other external features, the arrangement of the zoœcial apertures, and the character and marking of the interspaces should be noticed.

In the further progress of the investigation, which is now carried on chiefly by means of thin sections, it is necessary to determine the presence or absence, and the character of the "acanthopores," "median tubuli," "lunarium," zoœcial covers, and "hemisepta," the disposition and character of the "diaphragms" and "cystiphragms," and the minute structure and independence or amalgamation of adjoining zoœcial walls.

Acanthopores may be small (plate XV, figs. 15 and 17) or large (plate XXIII, fig. 35), and will generally have a very small cavity, but it may be comparatively large as in *Batostoma* (plate XXVII, fig. 10).

Median tubuli may be present between the mesial laminæ of bifoliate forms and between the erect portions of the zoœcia (plate IX, figs. 5 and 12).

The lunarium is shown in several types on plate 28. Zoœcial covers usually have a small subcentral perforation; they may be smooth (plate XXII, fig. 23) or with a radial ornamentation (plate XXIII, fig. 26). The opening may be laterally situated, and is often closed.

Hemisepta occur chiefly among the *Cryptostomata*. On plate VI, figs. 7*a* and 8 represent good examples of the superior one, while fig. 20 on plate XIV, shows the appearance of the inferior hemisepta.

Diaphragms may be remote or crowded (plate XXII, figs. 9, and 38), present in the axial region (see vertical sections on plate XXIII) or absent (plate XXVI, figs. 1 and 29). As a rule they are complete and straight, but they may be incomplete as in *Hemiphragma* (plate XXIV); and they are always more abundant in the mesopores than in the true zoœcial tubes. Cystiphragms when present, occur in conjunction with the diaphragms. Usually they overlap each other, as in most of the vertical sections on plate XVI. Occasionally they are separated and appear as semicircular lines lining one or both walls of the zoœcial tubes in vertical sections, as in fig. 16 of the same plate. In other cases they are oblique or funnel-shaped, as in figs. 3, 4, and 5, on plate XVII.

In most Bryozoa the walls of contiguous zoœcia are strictly independent and separable from each other, but in the *Ceramoporidæ* and *Fistuliporidæ*, they are completely fused together.

Among the remaining characters that are brought out by thin sections, it is important to observe the relative length and shape of the primitive or axial portion of the zoœcial tubes, and the strength and character of the curve in which they approach the surface.

CLASSIFICATION.

The class Bryozoa is divided by Ray Lankaster into two very unequal subclasses, the *Holobranchia*, in which the lophophore, or ring of tentacles, is unbroken and continuous, and the *Pterobranchia*, in which it is divided into two plumed arms or processes, bearing a resemblance to the branchial appendages of the Brachiopoda.

According to Nitsche the *Holobranchia* are again divisible into two very unequal groups, the *Ectoprocta*, in which the lophophore surrounds the mouth only, and the *Entoprocta*, in which it encloses both the orifices of the alimentary canal.

The former division embraces the great majority of the Bryozoa, and the second of the two orders, *Phylactolœmata* and *Gymnolœmata*, of Allman, into which it is almost universally divided, comprises, with very few exceptions, all the living and fossil marine forms. In the *Phylactolœmata* the lophophere is open on one side and horseshoe-shaped; in the *Gymnolœmata* it is complete and circular.

The second of these orders has been divided into five suborders, the *Chilostomata*, *Cryptostomata*, *Trepostomata*, *Cyclostomata*, and *Ctenostomata*, all of which seem to be represented in the paleozoic rocks of America.

SYSTEMATIC CLASSIFICATION OF PALEOZOIC BRYOZOA.*

Sub-kingdom MOLLUSCOIDEA.

Class BRYOZOA, Ehrenberg.

Sub-class HOLOBRANCHIA, Ray Lankester.

Order GYMNOLÆMATA, Allman.

Sub-order CHILOSTOMATA, Busk.

Orifice of zoœcium situated laterally, of smaller diameter than the zoœcium, closed by a movable cover (*operculum*). Ova usually matured in external marsupia. Appendicular organs (avicularia and vibracula) frequently present.

Family PALESCHARIDÆ, *Ulrich.*

Genus: *Paleschara* HALL.

Family WORTHENOPORIDÆ, *Ulrich.* (Provisional)

Genus: *Worthenopora* ULRICH.

Family PHACELOPORIDÆ, *Ulrich.*

Genus: *Phacelopora* ULRICH.

Suborder CRYPTOSTOMATA, Vine.

Primitive zoœcium as in the *Chilostomata.* Orifice concealed, at the bottom of a tubular shaft or vestibule, which may become intersected by straight diaphragms or hemisepta through the direct super-imposition of successively developed layers of polypides. External orifice rounded, often closed by a perforated or entire cover. External marsupia and avicularia wanting.

*The classification here published is a slight improvement upon the scheme in vol. viii, Ill. Geol. Sur. Rep'ts. That one represented the state of our knowledge on the subject in 1887-89.

Family PTILODICTYONIDÆ, *Zittel.*

Genera: *Ptilodictya* LONSDALE, *Clathropora* HALL, *Phænopora* HALL, *Graptodictya* ULRICH, *Arthropora* U., *Tæniodictya* U., *Ptilotrypa* U., *Stictotrypa* U., *Stictoporella* U., *Intrapora* HALL, *Coscinella* HALL.

Family RHINIDICTYONIDÆ, *Ulrich.*

Genera: *Rhinidictya* ULRICH, *Eurydictya* U., *Dicranopora* U., *Goniotrypa* U., *Euspilopora* U., *Phyllodictya* U., *Pachydictya* U., *Stictopora* HALL.

Family CYSTODICTYONIDÆ, *Ulrich.*

Genera: *Cystodictya* ULRICH, *Coscinium* KEYSERLING, *Dichotrypa* U., *Actinotrypa* U., *Tæniopora* NICHOLSON, *Prismopora* HALL, *Scalaripora* HALL, *Evactinopora* MEEK and WORTHEN, *Glyptopora* U., *Goniocladia* ETHRIDGE, *Acrogenia* HALL.

Family RHINOPORIDÆ, *Ulrich.*

Genus: *Rhinopora* HALL.

Family HELIOTRYPIDÆ, *Ulrich.*

Genus: *Heliotrypa* ULRICH.

Family ARTHROSTYLIDÆ, *Ulrich.*

Genera: *Arthrostylus* ULRICH, *Helopora* HALL, *Sceptropora* ULRICH, *Arthroclema* BILLINGS, *Nematopora* ULRICH, ? *Thamnotrypa* HALL.

Family RHABDOMESONTIDÆ, *Vine.*

Genera: *Rhabdomeson* YOUNG and YOUNG, *Cœloconus* ULRICH, *Rhombopora* MEEK, *Nemataxis* HALL, *Acanthoclema* HALL, *Bactropora* HALL, ? *Tropidopora* HALL.

Family STREBLOTRYPIDÆ, *Ulrich.*

Genera: *Streblotrypa* ULRICH, *Cyclopora* PROUT, ? *Proutella* ULRICH, ? *Cycloporella* U.

Family SPHRAGIOPORIDÆ, *Ulrich.*

Genus: *Sphragiopora* ULRICH.

Family FENESTELLIDÆ, *King.*

Genera: *Fenestella* LONSDALE, *Semicoscinium* PROUT, *Fenestrapora* HALL, *Isotrypa* HALL, *Tectulipora* HALL, *Unitrypa* HALL, *Hemitrypa* PHILLIPS, *Helicopora* CLAYPOLE, *Archimedes* LESUEUR, *Lyropora* HALL, *Fenestralia* PROUT, *Polypora* MCCOY, *Thamniscus* KING, *Phyllopora* KING, *Ptiloporina* HALL, *Ptiloporella* HALL, ? *Loculipora* HALL.

Family ACANTHOCLADIIDÆ, *Zittel.*

Genera: *Pinnatopora* VINE, *Septopora* PROUT, *Acanthocladia* KING, *Synocladia* KING, *Diplopora* YOUNG and YOUNG, *Ptilopora* MCCOY, ? *Icthyorachis* MCCOY, ? *Penniretepora* d'ORBIGNY, ? *Ramipora* TOULA.

Family PHYLLOPORINIDÆ, *Ulrich.*

Genera: *Phylloporina* ULRICH, *Chainodictyon* FOERSTE, *Drymotrypa* ULRICH, ? *Crisinella* HALL.

Suborder TREPOSTOMATA, Ulrich.

Zoœcia superimposed directly one upon the other so as to form long tubes intersected by straight or curved partitions (diaphragms and cystiphragms), representing the covers and floors of the successive layers. Two regions are distinguishable in the tubes, an axial or "immature" region in which the diaphragms are remote and the walls thin and prismatic; and a peripheral or "mature" region in which the walls are thickened and otherwise changed, the transverse partitions more abundant, and accessory elements, such as mesopores and acanthopores, developed. Zoœcial covers with a small central orifice.

Family MONTICULIPORIDÆ, *Nicholson.*

Genera: *Monticulipora* d'ORBIGNY, *Atactoporella* ULRICH, *Homotrypella* ULRICH, *Peronopora* NICHOLSON, *Homotrypa* U., *Prasopora* NICHOLSON and ETHRIDGE, *Mesotrypa* U.

Family HETEROTRYPIDÆ, *Ulrich.*

Genera: *Heterotrypa* NICHOLSON, *Dekayia* EDWARDS and HAIME, *Petigopora* U., *Dekayella* U.

Family CALLOPORIDÆ, *Ulrich.*

Genera: *Callopora* HALL, *Calloporella* U., ? *Aspidopora* U.

Family TREMATOPORIDÆ, *Ulrich.*

Genera: *Trematopora* HALL, *Nicholsonella* U., *Constellaria* DANA, *Stellipora* HALL, *Idiotrypa* U.

Family BATOSTOMELLIDÆ, *Ulrich.*

Genera: *Batostomella* U., *Stenopora* LONSDALE, *Anisotrypa* U., *Bythopora* MILLER and DYER, *Callotrypa* HALL, *Leioclema* U.

Family AMPLEXOPORIDÆ, *Ulrich.*

Genera: *Amplexopora* U., *Monotrypella* U., *Petalotrypa* U., *Atactopora* U., *Leptotrypa* U., ? *Discotrypa* U.

Family DIPLOTRYPIDÆ, *Ulrich.*

Genera: *Diplotrypa* NICHOLSON, *Monotrypa* NICHOLSON, *Batostoma* U., ? *Hemiphragma* U.

Family CERAMOPORIDÆ, *Ulrich.*

Genera: *Ceramopora* HALL, *Ceramoporella* U., *Crepipora* U., *Diamesopora* HALL, *Chiloporella* U., *Ceramophylla* U., *Anolotichia* U., *Spatiopora* U.

Family FISTULIPORIDÆ, *Ulrich.*

Genera: *Fistulipora* McCoy, *Eridopora* U., *Chilotrypa* U., *Meekopora* U., *Strotopora* U., *Lichenotrypa* U., *Buskopora* U., *Selenopora* HALL, *Pinacotrypa* U.

Family BOTRYLLOPORIDÆ, *Miller.*

Genus: *Botryllopora* NICHOLSON.

Suborder CYCLOSTOMATA, Busk.

Zoœcia very simple, tubular, with a plain, inoperculate, circular orifice; wall thin, minutely porous. Marsupia and appendicular organs wanting.

Family TUBULIPORIDÆ, *Busk.*

Genera: *Stomatopora* BRONN, *Proboscina* AUDOUIN, *Berenicea* LAMOUROUX, *Diastoporina* U., ? *Hedrella* HALL, ? *Hernodia* HALL, ? *Reptaria* ROLLE.

Family FRONDIPORIDÆ, *Reuss.*

Genus: *Scenellopora* ULRICH.

Family ENTALOPHORIDÆ, *Reuss.*

Genera: *Clonopora* HALL, *Mitoclema* U., *Diploclema* U., *Protocrisina* U., ? *Cystopora* HALL.

Suborder CTENOSTOMATA, Busk.

Zoœcia usually isolated and developed by budding from the internodes of a distinct tubular stolon or stem. Orifice terminal, closed by an operculum of setæ. Zoarium horny or membranaceous. Marsupia wanting.

Family ASCODICTYONIDÆ, *Ulrich.*

Genera: *Ascodictyon* NICHOLSON and ETHRIDGE, *Rhopalonaria* U., *Vinella* U.

GEOLOGICAL DISTRIBUTION.

It is a singular fact that no remains whatever of Bryozoa are known from rocks of earlier date than the Chazy limestone of the Lower Silurian System. Here the class suddenly leaps into a prominence, not only in the way of individual representation, but in the matter of diversity of structure, that is both surprising and difficult of explanation. Nor was it, as might be expected, the simpler types that prevailed here. On the contrary, it is the more complex types like the *Trepostomata* and *Cryptostomata* that are the most abundant and diverse in their development. What may be even more surprising is that every suborder known in the fossil state was represented before the close of the Lower Silurian era.

The vertical range of a few of the Lower Silurian genera (*Stomatpora* and *Berenicea*), is likewise remarkable, and not equalled, so far as known, in any other class of animals, excepting the Brachiopoda, of which the genus *Lingula*, the same as the bryozoan genera alluded to, has living representatives. Still, as a rule, the vertical range of Bryozoa is restricted to comparatively narrow limits, and most genera and many families fail to pass from one system of rocks to the next.

Lower Silurian System: As has been stated, true Bryozoa are first met with in the Chazy rocks of this system. In this group, excepting some of the calcareous strata in New York and Canada, originally referred here, the conditions were often quite unfavorable, not only for their preservation but for their development as well. In the excepted beds several species of *Phylloporina* and *Rhinidictya* belonging to the *Cryptostomata*, a considerable number of mostly undetermined *Trepostomata*, and *Mitoclema*, a genus of the *Cyclostomata*, have been found. Following the rocks westward from Canada the calcareous beds are lost, but the arenaceous portion, there known as the St. Peter sandstone, a formation totally unfitted for their preservation, increases in thickness, and in Minnesota seems to be the only representative of the formation. The marble beds at Knoxville, Tennessee, which probably belong to the Chazy, are full of the remains of *Trepostomata*, none of which have, as far as we know, yet received critical study.

Following the Chazy are the Birdseye and Black River limestones and shales. The first of these divisions has a wide geographical distribution, being known from New York and Canada to Tennessee and Kentucky, as a fine-grained, massive or in parts somewhat shaly limestone. The shaly layers are full of Bryozoa, among which the *Cryptostomata* are preeminently developed. In Minnesota the greater part of the "Trenton limestone" and the lower two-thirds of the shales resting on it, are probably equivalent strata. Here the limestone is comparatively barren of Bryozoa, but the shales, on the contrary, are exceedingly rich, affording also a greater diversity of structure than is known from any of the more southern and eastern localities for the group.

Among the *Cryptostomata*, both the *Ptilodictyonidæ* and *Rhinidictyonidæ* reach their maximum development in this group, while the *Arthrostylidæ* and *Phylloporinidæ* are both well represented. The *Trepostomata* likewise are strongly represented, and in the Minnesota shales of the group every family of the suborder has been recognized. The *Cyclostomata* come in with *Stomatopora proutana*, a species that is continuously present to the top of the Lower Silurian, and *Berenicea*.

In the Trenton limestones and shales proper, the *Cryptostomata* have lost some of their strength, whilst that of the *Trepostomata* is increased by the addition of several genera—*Prasopora, Monticulipora, Stellipora* and *Diamesopora*. The *Cyclostomata* add *Protocrisina, Diploclema, Scenellopora*, and *Diastoporina*.

Nearly all the genera now introduced continue to the top of the Lower Silurian, and before the close of the era we find a representative of the last of the five suborders, the *Chilostomata*, in a species of *Paleschara*. The *Trepostomata*, however, again add greatly to their numbers in the Cincinnati group, in which nearly 200 distinguishable forms of this suborder are known to me. These belong to 35 genera, giving every family, with the exception of the *Fistuliporidæ*, a strong representation. Of the *Cyclostomata* also the indivividuals and species became more numerous, while the *Ctenostomata* added another species of *Vinella* and the new genus *Rhopalonaria*.

UPPER SILURIAN SYSTEM: The Bryozoa in the rocks of this system are very different from those of the Lower Silurian. The *Trepostomata* are greatly reduced by the almost total extinction of the families *Monticuliporidæ* and *Heterotrypidæ*, and a considerable reduction in the *Calloporidæ, Amplexoporidæ, Diplotrypidæ*, and the *Ceramoporidæ*. But the *Fistuliporidæ*, a family that reached its greatest development in Devonian and Subcarboniferous times, became prominent here. Of the *Cyclostomata* we have only *Diploclema sparsum*, a Niagara fossil, of the *Ctenostomata*, a few species, and of the *Chilostomata*, likewise only a few forms of *Paleschara*. But the *Cryptostomata* inaugurate a new and vigorous start. Two new genera, *Clathropora* and *Stictotrypa*, are added to the *Ptilodictyonidæ*, while the genera *Ptilodictya*, and *Phænopora*, of the same family, became fully established. *Rhinidictya, Pachydictya Phylloporina, Drymotrypa, Helopora* and *Nematopora*, belonging to three other families of the suborder, are also well represented. The *Fenestellidæ*, of which but a single Lower Silurian species is known, increase in abundance and variety from the Clinton to the Lower Helderberg, in which most of the generic types of the family, some of them, however, not yet fully established, are already distinguishable. Numerous species of *Fenestella* and *Polypora*, and one or more each of *Unitrypa, Hemitrypa*, *Isotrypa, Tectulipora, Semicoscinium, Ptiloporina,* and *Helicopora,* have been described. The *Acanthocladiidæ* begin in the Lower Helderberg with a few species of *Pinnatopora* and *Icthyorachis,* and *Rhombopora,* belonging to another family of the suborder, has one species in the Niagara and several in the Lower Helderberg. The *Cystodictyonidæ,* essentially a Devonian and Carboniferous family, is also met with for the first time, a species of *Dichotrypa* having been described from the Niagara of Illinois, and one or two of *Cystodictya* from the Lower Helderberg of New York. *Rhinopora* is known only from the Clinton.

The absence of so many characteristic Lower Silurian types, and the presence of most of the genera that are strongly developed in the Devonian, proves, so far as the Bryozoa are concerned, that the break between the Lower and Upper Silurian is sharper than the one between the Upper Silurian and the Devonian.

DEVONIAN SYSTEM: Several hundred species of Bryozoa have been described from the rocks of this age. The great mass of these are *Cryptostomata,* and of these the majority belong to the *Fenestellidæ.* Every genus of this family, excepting *Fenestralia, Lyropora* and *Archimedes,* is more or less largely represented. To the same suborder belong *Cystodictya, Dichtyotrypa, Prismopora, Scalaripora, Coscinium Tæniopora, Glyptopora,* and *Acrogenia,* of the *Cystodictyonidæ;* a Corniferous species of *Ptilodictya* (the last known of the genus), *Taeniodictya, Intrapora,* and *Coscinella,* of the *Ptilodictyonidæ; Euspillopora,* of the *Rhinidictyonidæ; Rhombopora, Nemataxis, Acanthoclema,* and *Bactropora,* of the *Rhabdomesontidæ; Streblotrypa;* and *Pinnatopora* and *Ptilopora* of the *Acanthocladiidæ.* The *Cyclostomata* are included in the genera *Clonopora, Cystopora, Hederella, Hernodia,* and *Reptaria; Ascodictyon* represents the *Ctenostomata.* The *Trepostomata* are represented chiefly by numerous species of *Fistulipora* and one or more of *Eridopora, Chilotrypa, Meekopora, Strotopora, Lichenotrypa, Buskopora, Selenopora, Pinnacotrypa, Botryllopora, Monotrypella, Amplexopora, Petalotrypa Batostomella, Leioclema,* and *Dekayia.*

SUB-CARBONIFEROUS SYSTEM: The Bryozoa of this age are very similar to those of the Devonian, and the majority of the genera of either are common to both systems. The principal difference is found in the absence of some of the peculiarly modified Devonian types of the *Fenestellidæ,* like *Unitrypa, Loculipora, Fenestropora,* etc. They are, however, replaced by the equally interesting genera *Archimedes, Lyropora* and *Fenestralia.* Among the *Cystodictyonidæ* we miss *Scalaripora* and *Acrogenia,* but their vacant places are more than filled by the remarkable genera *Evactinopora* and *Actinotrypa.* Other *Cryptostomata* are *Tæniodictya, ? Stictoporella, Pinnatopora, Septopora, Ptilopora, Diplopora, Sphragiopora, Cœloconus, Rhombopora, Bactropora, Acanthoclema, Streblotrypa, Cyclopora, Proutella* and *Heliotrypa.* The three last named, together with *Worthenopora*, belonging to the *Chilostomata*, are new types. Among the *Trepostomata*, the *Fistuliporidæ* are abundant, and *Stenopora, Leioclema, Anisotrypa*, and *Batostomella* not uncommon. Both the *Cyclostomata* and *Ctenostomata* are poorly represented, each by one or two insignificant species.

CARBONIFEROUS SYSTEM: The rocks of this age are mostly unfavorable for the preservation of the Bryozoa, and only a few localities are known in this country where good specimens may be obtained. With the exception of *Stenopora* and *Fistulipora* all the observed forms belong to the cryptostomatous genera *Fenestella, Polypora, Thamniscus, Acanthocladia, Pinnatopora, Septopora, Diplopora, Sphragiopora, Chainodictyon, Prismopora, Cystodictya*, and *Rhombopora*.

In America Bryozoa are rare or entirely unknown in the strata above the paleozoic. Most of the species known are from the Cretaceous and Tertiary rocks of New Jersey, Mississippi and Arkansas. In Europe the Triassic system is equally poor in Bryozoa, but in the Jurassic they are represented by nearly eighty species, most of them *Cyclostomata*. This suborder continues to be almost exclusively represented to the Cenomanian in which the *Chilostomata* are present, though not yet in very great numbers. Even in the Upper Cretaceous, from which d'Orbigny mentions 662 species, the *Cyclostomata* and *Trepostomata* are nearly twice as numerous as the *Chilostomata*. In the Tertiary rocks the *Cyclostomata* have become less numerous and the *Chilostomata* more abundant, the ratio of representation at the close of the age being approximately like the present.

Class BRYOZOA, Ehrenberg.

Order GYMNOLÆMATA, Allmann.

Sub-order CTENOSTOMATA, Busk.

Family ASCODICTYONIDÆ, Ulrich.

Genus VINELLA, Ulrich.

Vinella, ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 173.

Zoarium attached to foreign bodies (shells, etc.), consisting of exceedingly slender, ramifying, thread-like, tubular stolons, arranged more or less distinctly in a radial manner. Surface of tubes sometimes faintly lined longitudinally. A row of widely separated small pores along the center of the surface of the tubes. Zoœcia unknown.

Type: *Vinella repens* Ulrich.

The fossils for whose reception this genus was proposed are regarded as related to *Vesicularia*, Thompson, and probably also to *Mimosella*, Hincks, both of them genera of recent Bryozoa. The zoœcia must have been deciduous and developed by budding from the creeping stolons at the points now represented by the small pores. The form that is designated the type of the genus, though one of the rare fossils of the Trenton shales of Minnesota, is justly entitled to that distinction, because it is, so far as our knowledge at present extends, the earliest existence of the genus. Similar organisms are known to occur more or less rarely in the Hudson River, Niagara, ? Hamilton and Chester groups of rocks in America, while in the Wenlock of England and Gotland, the *Ascodictyon radiciformis* Vine, is unquestionably a congeneric form. Still another form that I would refer to this sub-order is represented in my collection by several zoaria from the Upper Coal Measures at Springfield, Illinois.

In the absence of the zoœcia a satisfactory classification of these mostly obscure organisms is perhaps impossible. Our observations are limited to the creeping stolons which, even in the recent *Ctenostomata*, are but illy diagnostic of generic types. Better material, carefully studied, may later on demonstrate the advisability of erecting other genera for some of the types now classed as *Ascodictyon* and *Vinella*. In the present state of our knowledge it is also most difficult to decide the exact limits of the genus *Ascodictyon*, Nicholson and Ethridge, jun., and the only plan that now appears feasible is to include all, and only such forms as possess the ovate or pyriform vesicles. As *Vinella,* on the other hand, I would class those forms in which they are absent. According to this arrangement the *Ascodictyon radiciformis* Vine, would fall under *Vinella.* Not so, however, the *A. filiforme* of the same author. This species, so far as I can learn, even in its most simple form, has always an occasional "lagena-like vesicle developed on the sides of the thread," while some of its more complex varieties make a decided approach toward the Devonian type of the genus, *A. stellatum* Nicholson and Ethridge, jun.

In the accompanying cut (fig. 8), *a* represents a cluster of vesicles of *Ascodictyon stellatum,* with a portion of the delicate stolon that connected it with similar clusters. One example in my collection consists of eight of such clusters. In the majority of the specimens seen, however, the clusters are much less regular, and in many cases the vesicles are distributed with little or no regularity over the surface of the body to which the zoarium is attached. In all cases, when the fossil is in a good state of preservation, these vesicles, whether isolated or arranged in radial aggregations will be found to be connected with each other by a delicate filament; and in this species at least, the surface of the vesicles exhibits a large number of minute pores.

FIG. 8.

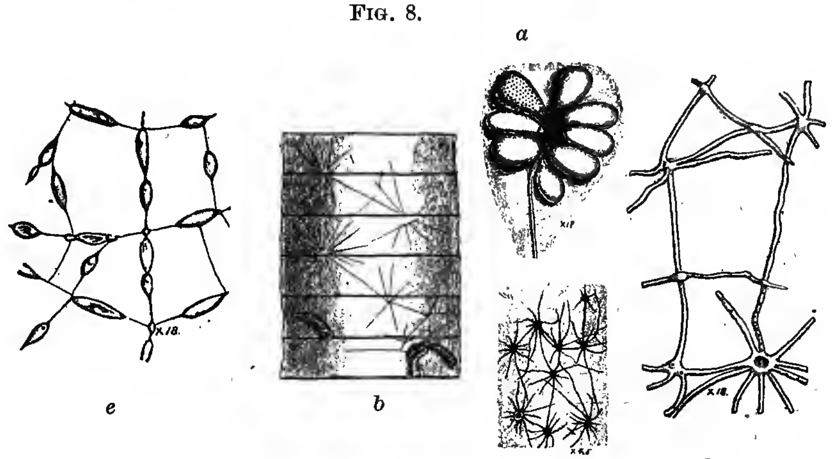


Figure *b* of the same cut represents a natural size view of the only specimen seen of the Cincinnati form, that I propose naming VINELLA RADIALIS. It consists of four principal colonies or nuclei, growing upon an *Orthoceras.* Only the form is preserved, and even that not well. However, sufficient remains to show that it belongs to an undescribed species, with the probabilities greatly in favor of *Vinella* as its final resting place. The radial arrangement is more regular, and the radii straighter than in any other form of the genus known to me.

Figures *c* and *d* of the same cut illustrate an unquestionable species of *Vinella,* of which a number of excellent specimens were collected in the Niagara shales near Waldron, Indiana. One of the figures is magnified four and a half diameters, the other eighteen. In the absence of good examples of the English Wenlock species, *Vinella radiciformis* Vine, sp., which these specimens must greatly resemble, I propose to designate the American form provisionally as var. CONFERTA, in allusion to the unusually close development of the nuclei.

The inclusion of all the paleozoic *Ctenostomata* in one family, the *Ascodictyonidæ*, (see Geol. Sur. Ill., vol. viii, p. 335) is likewise only a provisional arrangement. Indeed, I am satisfied that *Rhopalonaria*, Ulrich, at least, which is evidently related to the recent *Arachnidium*, Hincks, belongs to a distinct family.

Figure 8*e* is taken from the best example of *Rhopalonaria venosa* Ulrich, now at hand.* This species, so far as known, is restricted to the upper beds of the Hudson River group, and the specimen now illustrated is from those beds at Waynesville, Ohio. Usually nothing remains to attest the former presence of this bryozoan, except a series of shallow excavations in the substance of the body upon which it grew. These excavations, however, correspond very well with the form, or rather, the outline of the cells and extremely delicate connecting stolons of the zoarium itself. The latter must have been quite liable to destruction during the process of fossilization, and, though diligently searched for, not a single example, so far as I am aware, has yet been found in which it is preserved in even a fairly satisfactory manner. In the best specimens the stolons are clear enough, but the swollen portion of the zoœcia is always more or less obscure. Now and then, it is true, some evidence is presented to show that the orifice was situated near one end in the center of a slightly elevated portion of the surface. These facts, though unfortunate, tend nevertheless to establish the ctenostomatous affinities of the fossil. If, as already intimated, *Rhopalonaria* is related to *Arachnidium*, then perfect zoarial preservation is not to be expected. On the contrary, if such a condition were common, as in calcareous zoaria, the relationship might well be doubted, since the almost membranaceous zoarium of *Arachnidium* and many other *Ctenostomata*, is, perhaps, quite incapable of preservation in a fossilized state.

VINELLA REPENS *Ulrich.*

PLATE I, FIGS. 1-5.

Vinella repens ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 174.

Original description.—"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 radial manner about a central node. Where best preserved, very small pores arranged uniserially along the center of the

*The original type of the genus and species has been mislaid or lost.

upper surface of the threads; about eleven in 2.5 mm. Zoœcia unknown, probably deciduous."

In the Hudson River species, *V. radialis*, the average thickness of the stolons is a little less. They are also straighter and arranged quite regularly in a radial manner. In the Niagara form, *V. radiciformis*, var. *conferta*, the stolons are likewise more slender and the nuclei much more frequent.

Formation and locality—Rare in the upper third of the Trenton shales at St. Paul, Minnesota. All the specimens seen have grown upon valves of *Strophomena septata* Winchell and Schuchert.

Sub-order CYCLOSTOMATA, Busk.

Genus STOMATOPORA, Bronn.

Alecto, LAMX., 1821, BLAINVILLE, JOHNSTON, M. EDWARDS, BUSK, etc. (Not *Alecto*, Leach, 1814.)
Stomatopora, BRONN, 1825, Pflanzenth., p. 27. D'ORBIGNY, 1852, Pal. Franc. t. v, p. 833. HAIME, 1854, Bry. Foss. Form. Jurassic, p. 159. ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 149, and 1890, Geol. Sur. Ill., vol. viii, p. 367. MILLER, 1889, N. Amer. Geol. and Pal., p. 325.
Stomatopora (part.), HINCKS, 1880, Brit. Mar. Polyz., p. 424.
Aulopora (part.), GOLDFUSS, REUSS, HALL, NICHOLSON.

Zoaria adnate; zoæcia subtubular, club-shaped, or ovate, not immersed, arranged in single branching series; apertures subterminal, more or less elevated, circular; walls finely porous.

Type: *Alecto dichotoma* Lamouroux.

In drawing up this diagnosis I continue to follow Jules Haime and d'Orbigny in discriminating between the uniserial and multiserial forms, despite the fact that a tendency to unite them under one name has of late become manifest. Hincks, for instance, places species here having precisely the same zoarial habits as the *Proboscina frondosa* (pl. I, fig. 28) of the Hudson River rocks. He would probably go far enough in this direction to include even *Berenicea minnesotensis.* And yet he retains *Diastopora*, with *Berenicea* as a synonym. The resulting classification is, to my mind, anything but satisfactory. With me the greatest difficulty is, not to separate the uniserial forms, but to draw a line between *Berenicea* (as typified by *B. diluviana* Lamouroux) and the bi- and multiserial forms of which *Proboscina auloporoidea* Nicholson, sp., *P. tumulosa*, *P. frondosa* Nicholson, sp., and *Berenicea minnesotensis* are progressive examples. That some of these, and several Secondary, Tertiary and recent species of this type, sometimes have the zoœcia arranged uniserially at the base and at the beginning of the branches is scarcely a sufficient reason for regarding them as congeneric with such invariably uniserial forms as *Stomatopora dichotoma* Lamouroux, *S. proutana* S. A. Miller, *S. inflata* Hall, sp., and a host of others. As I view the matter, the former in their mature or ultimate development, are much nearer *Berenicea* (Lamouroux, Haime, Zittel and others; *Diastopora* of Busk and other British authors). Sharply defined genera are an impossibility in nature. She follows paths altogether too intricate to be expressed in a system of classification. The best result that we can obtain must be a happy medium between convenience and natural affinity. Convenience, and stability as well, are surely sacrificed when we throw together a number of genera and then divide the composite genus, that has now been made to assume the rank of very nearly a family, into sections of questionable utility that no one is obliged to recognize, because they have no established validity in any system of classification. Is it not better, because it is convenient and saves time, to have it understood at once that when one says *Stomatopora*, he refers to uniserial forms; *Proboscina*, to forms with similar zoœcia but partly immersed and in two or more series, and *Berenicea*, to such as have them forming entire, flabellate, circular or irregular crusts?

The only change from the arrangement here retained that I am willing to enter into, and for which good and probably sufficient reasons can be advanced, is one that would drop *Proboscina*, leaving *Stomatopora* to stand as at present for the uniserial species, and extend *Berenicea* so as to include the ground now occupied by *Proboscina.*

STOMATOPORA TENUISSIMA *Ulrich.*

PLATE I, FIGS. 6 and 7.

Stomatopora tenuissima ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 175.

Original description.—"Zoarium adnate, consisting of frequently branching uniserially arranged zoœcia. Zoœcia exceedingly slender, about seven in 8 mm., 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 zoœcium.

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

Formation nad locality.—Toward the top of the Utica horizon of the Hudson River group at Cincinnati, Ohio, 150 to 175 feet above low water mark in the Ohio river.

Stomatopora proutana *S. A. Miller.*

PLATE I, FIGS. 8-12.

Stomatopora proutana S. A. Miller, 1882. Jour. Cin. Soc. Nat. Hist., vol. v, p. 39.
Ropalonaria pertenuis Ulrich, 1886. Fourteenth Ann. Rept. Geol. Nat. Hist. Sur. Minn., p. 59.

Zoarium adnate, consisting of frequently branching, uniserially arranged zoœcia. Zoœcia slender, clavate, about 0.04 mm. in diameter at the proximal end, increasing gradually in size to from 0.12 to 0.15 mm. at the rounded anterior end; each 0.6 to 0.8 mm. long, with from eight to ten in 5 mm. Aperture subterminal, small, circular, with a slightly elevated rim-like border; 0.05 to 0.06 mm. in diameter.

The above describes the usual form of the species, but fig. 12 represents a variety occurring in the lower layers of the Trenton shales of Minnesota, and in the "Pierce" limestone of Tennessee, having unusually large zoœcia. In this their length varies from 0.8 to 1.1 mm., while the diameter in the anterior third is generally over 0.2 mm., and sometimes as much as 0.3 mm.

In my preliminary report on the Minnesota Bryozoa this species was erroneously placed under the ctenostomatous genus *Rhopalonaria.* At the time I thought it advisable to extend the limits of that genus so as to include these delicate species of *Stomatopora.* Later studies have fully demonstrated the fallacy of such a view.

Compared with American species, only *S. tenuissima* and *S. inflata* Hall, sp., will be found to exhibit any close relations. In the first the zoœcia are more slender and longer; in the second they are much more inflated. *S. elongata* Vine, from the Wenlock of England, has slightly shorter zoœcia of a form very nearly intermediate between those of *S. proutana* and *S. inflata.*

Formation and locality.—This species occurs in the "Pierce" limestone of Tennessee, the Birdseye limestone of central Kentucky, and the Trenton shales of Minnesota at Minneapolis, St. Paul and Cannon Falls; also at Decorah, Iowa. So far it has not been recognized in the Galena, but it is to be found, rather rarely though, in the Utica horizon at Cincinnati, Ohio, and more abundantly near the tops of the hills at that locality. It occurs also higher in the Hudson River rocks at several localities in Ohio and Indiana, and at Wilmington, Illinois.

Mus. Reg. Nos. 5926, 8066.

Stomatopora inflata *Hall.*

PLATE I, FIGS. 13-21.

Alecto inflata Hall, 1847. Pal. N. Y., vol. i, p. 77.
Hippothoa inflata Nicholson, 1875. Pal. Ohio, vol. ii, p. 268.
Stomatopora inflata Vine, Nov., 1881. Quar. Jour. Geol. Soc. London.

Zoœcia resembling those of *Hippothoa,* short and wide when compared with the preceding species, pyriform, the proximal end contracted and springing from the under side of the anterior end of the cell beneath; eight or nine in 5 mm. Apertures circular, direct, with a peristome, about 0.09 mm. in diameter, situated near the anterior end. Mural perforations minute and but rarely preserved.

In the Trenton or typical form of this species the zooecia, as a rule, are less swollen and the adnate zoarium divides less frequently than in the better known Cincinnati form. In the latter, therefore, the network is closer, and occasionally the growth is so luxuriant that the rows cross each other to such an extent that but little space is left between the cells. No distinction, however, can be based upon these characters since, when good series of specimens are studied, it is found that among those from Trenton localities some have more than commonly swollen and crowded cells, while in some of those from the geologically higher localities the growth is lax and the zooecia comparatively narrow.

Formation and locality.—Trenton group, at Trenton Falls, New York; Ottawa, Canada; Cannon Falls, and other localities in Minnesota where the upper third of the Trenton shales are exposed; Hudson River group at Cincinnati, Ohio, (350 to 425 feet above low water mark in the Ohio river), and in the upper beds at Richmond, Indiana; Wilmington and Savannah, Illinois, and other localities.

Mus. Reg. Nos. 5924, 8045.

STOMATOPORA TURGIDA *Ulrich.*

PLATE I, FIGS. 22 and 23.

Stomatopora turgida ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 176.

Original description.—"Zoarium adnate, consisting of a single branching series of zooecia. Zooecia 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 zooecium. Five zooecia in 5 mm.; length of each zooecium 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 the zœocium from its anterior end.

"I have a number of specimens of this species, and all consist of comparatively few zooecia. 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. *S. turgida* is further distinguished from that and all other species of the genus known to me, by the much larger zooecia."

Formation and locality.—Upper beds of the Hudson River group at Wilmington, Illinois.

Genus PROBOSCINA, Audouin.

Proboscina (part.), AUDOUIN in Savigny, Desc. de l'Egypte, Pol., p. 236, 1826.
Proboscina, d'ORBIGNY, 1852, Pal. Fr. terr. cret., t. v, p. 844. HAIME, 1854, Bry. de la form. Jurass., p. 10. Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 149, and 1890, Geol. Sur. Ill., vol. viii, p. 368.
Not *Proboscina*, of SMITT and others.

Zoaria wholly adnate. Zoœcia as in *Stomatopora*, excepting that they are more or less immersed and not uniserial, being arranged in two or more contiguous rows.

For remarks relating to this genus see under *Stomatopora*.

PROBOSCINA TUMULOSA, *n. sp.*

PLATE I, FIG. 24.

Zoarium adnate, branching dichotomously, or inosculating, in the latter case forming an irregular large-meshed network. Branches narrow, generally with two or three, rarely four or five, alternating series of cells. Zoœcia subpyriform, or obovate, not wholly immersed, generally appearing as bulbous swellings on the surface of the zoarium. Apertures subterminal, contracted, circular, slightly oblique, about 0.09 mm. in diameter, with a slight peristome. About five or six cells in 3.0 mm.

Compared with *Proboscina frondosa* (plate I, fig. 28) and *P. auloporoidea* (both Nicholson, sp.), two Hudson River forms, this species is distinguished by its shorter and more bulbous zoœcia, their shape being more like those of *Stomatopora inflata* and *Berenicea minnesotensis*. The resemblance to the last is so marked that I would not be surprised if coming discoveries prove *P. tumulosa* directly descended from it.

Formation and locality.—Rare in the upper third of the Trenton shales at St. Paul; more abundant in the same beds near Cannon Falls, Minnesota.

Mus. Reg. Nos. 7620, 8047, 8101.

PROBOSCINA FRONDOSA *Nicholson.*

PLATE I, FIG. 28.

Alecto frondosa NICHOLSON, 1875. Pal. Ohio, vol. ii, p. 266.
Proboscina frondosa ULRICH, 1889. Contri. to the Micro-Pal. of Canada, pt. ii, p. 28.

A figure, taken from an excellently preserved example of this species, is introduced for the better understanding of, and comparison with, Minnesota *Cyclostomata*. This specimen is from the hill quarries at Cincinnati, Ohio, but the species also occurs in the upper beds of the formation at many localities in Ohio, Kentucky and Indiana, at Nashville, Tennessee, Wilmington and Savannah in Illinois, and at Stony Mountain, Manitoba. My belief that it will yet be found at Spring Valley, Minnesota, and other points in the southern part of the state, where equivalent beds are exposed, is therefore within the bounds of probability.

Mus. Reg. No. 8102.

Genus BERENICEA, Lamouroux.

Berenicea (part.), LAMOUROUX, 1821. Exp. meth. des genres de pol., p. 80.
Rosacilla, F. A. ROEMER, 1840, Verst. des norddeutsch. Kreidegeb., p. 19.
Berenicea, d'ORBIGNY, 1852. Pal. Fr. terr. cret., t. v, p. 858. J. HAIME, 1854, Bry de la form. Jurass., p. 19. ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p 194, and 1890, Geol Sur. Ill., vol. viii, p. 368.
Diastopora, d'ORBIGNY, 1850, and BUSK and other English authors. (Not Lamouroux.)
Diastopora (part.), HINCKS, VINE and others,
Saganella, HALL, 1852. Pal. N. Y., vol. ii, p. 172.
Diastoporella, VINE, 1883. Brit. Assoc. Rep. Foss. Pol., iii; and Proc. Yorks. Geol. Soc., n. s., vol. ix, pt. ii, p. 190.

Zoaria incrusting, forming circular or irregular patches. Individual zoœcia as in *Stomatopora* and *Proboscina*, but contiguously arranged in more or less regular spreading series.

Type: *B. diluviana* Lamouroux.

For remarks relating to this genus see under *Stomatopora*.

BERENICEA MINNESOTENSIS *Ulrich.*

PLATE I, FIGS. 25, 27 and 29; PLATE II, FIG. 1.

Berenicea minnesotensis ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 58.

Zoarium forming exceedingly thin, irregular crusts upon foreign bodies. The crust may be entire, with irregularly distributed and unequal non-celluliferous spots, or, especially at the edges of large expansions, it may throw off broad branches and include a few open spaces. In one example, provisionally referred here, the latter are so large and conspicuous that the zoarium may well be described as consisting of wide, irregularly inosculating branches.* Ordinarily the crust is nearly entire, and the non-celluliferous spaces, which, like the rest of the surface between the zoœcial apertures, are marked with obscure transverse lines or wrinkles, constitute a conspicuous feature. Zoœcia more or less immersed, in the latter condition appearing as subelliptical convex spaces, about 0.2 mm. wide, with an oblique circular aperture, 0.13 mm. in diameter, at their upper ends. In such examples (see fig. 29) the aperture is scarcely produced, but in others, more matured, it is prominent, while all the remainder of the cell is completely immersed. The arrangement of the zoœcia is,

*Perhaps this specimen is to be considered as indicating a departure that later on resulted in *Proboscina tumulosa* of this work.

on the whole, inclined to be irregular, though fairly regular longitudinal series, and sometimes diagonally intersecting rows can generally be made out. The average number in 2 mm. is five or six.

Compared with *B. primitiva* Ulrich, from the Hudson River group of Ohio, this species is distinguished by its larger and less tubular zoœcia, the interstitial wrinkles, and the non-celluliferous spaces. *B. vesiculosa* Ulrich, from the Utica shales horizon at Cincinnati, is a nearer relative, but also has smaller zoœcia, with the apertures less prominent. In most respects the position of the Minnesota species is intermediate between the two Ohio species.

Formation and locality.—Not uncommon in the lower and middle beds of the Trenton shales, at Minneapolis and St. Paul, Minnesota.

Mus. Reg. No. 5925.

Genus DIASTOPORINA, Ulrich.

Diastoporina, Ulrich, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 177.

Zoarium bifoliate, in general resembling *Diastopora* (Lamouroux, not Busk). Zoœcia subtubular, prostrate, immersed; apertures constricted, subcircular, not prominent. Interspaces finely punctate and striated longitudinally.

As only one species is known, it is difficult, if, indeed, it is not impossible in all such cases, to determine the really essential characters of the genus. The striation of the interspaces is a peculiar feature and the chief ground for separating the species from *Diastopora*, a genus so far not known in strata older than Jurassic. The Minnesota species, however, presents many points of agreement with species of that well known genus, and it may yet be shown that it represents merely an early type of same. This resemblance or possible relationship is paralleled in *Mitoclema*, Ulrich, and *Entalophora*, Lamouroux; *Diploclema*, Ulrich and *Bidiastopora*, d'Orbigny; *Protocrisina*, Ulrich, and *Crisina*, d'Orbigny; and *Scenellpora*, Ulrich, and *Defrancia*, Bronn, and *Discocavea*, d'Orbigny. In each case the first is founded upon lower paleozoic species, while none of the genera with which they compare are as yet known in rocks earlier than Jurassic. With the exception of *Entalophora* (*?Mito clema*) one or more species of which occur in the Devonian at the Falls of the Ohio, and in New York (*Clonopora*, Hall, 1887, Pal. N. Y., vol. vi), none of these cyclostomatous genera are known to have had an existence in Devonian and Carboniferous times. Precisely the same is true of *Stomatopora*, *Proboscina*, and *Berenicea*.* But

* Since writing the above, a paper has been received from the Canadian Geological Survey, in which Prof. J. F. Whiteaves describes one species each of *Stomatopora* and *Proboscina*, from the Devonian rocks of the far north. At my request, Prof. Whiteaves kindly sent me the types of the two species. These were carefully examined by me, with the result, that I still hold that we have no positive evidence of the existence of these genera in Devonian deposits. The first is unquestionably very closely related to *Rhopalonaria botellus* Vine, and not a *Stomotopora*. The other may be a *Proboscina*, but it is so different from any type of that genus known to me that I am obliged to view its relations as highly problematical.

in these cases the Lower and Upper Silurian species are so nearly like the Secondary, Tertiary, and recent forms of the genera, that a generic separation has so far seemed impracticable. And yet, considering their apparent absence in the Devonian and Carboniferous deposits, would we not be justified in denying the lineal descent of the recent forms from the early paleozoic species? However, questions of this kind cannot be considered as they deserve in the space here at my disposal, and, as they are also a little out of place in a publication of this kind, they will be merely touched upon, leaving their real discussion for some more fitting occasion.

DIASTOPORINA FLABELLATA *Ulrich.*

PLATE II, FIGS. 2 AND 3.

Diastoporina flabellata ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 176.

Zoarium small, arising from an attached basal expansion into thin flabellate fronds. The largest and only complete example seen is 5.5 mm. wide. Surface with obscure concentric wrinkles, and fine interrupted striations arranged parallel with the direction of the zoœcia. Under a high power of magnification the latter appear as delicate lines separating rows of exceedingly minute pores. Zoœcia rather scattering, in young examples partly exposed, appearing as convex oval spaces with a small oblique aperture, about 0.05 mm. in diameter and but little, if at all, elevated at the distal extremity. In some fragments of seemingly older examples the entire cell is immersed, leaving only the aperture, which, in these cases, is nearly direct and subtubular, to project over the nearly even surface. Their arrangement is often quite irregular, particularly in the vicinity of certain small non-celluliferous spots, but where rows are to be made out, about six or seven apertures occur in 2 mm.

This is the only bifoliate cyclostomatus bryozoan known to me in paleozoic rocks.

Formation and locality—Rare in the Galena shales near Cannon Falls and at St. Paul, Minnesota. At the first locality it is associated with a very interesting fauna, consisting principally of *Ostracoda* and minute bryozoans, among the latter species of *Nematopora*, *Helopora* and *Arthroclema.*

Genus MITOCLEMA, Ulrich.

Mitoclema, ULRICH, 1882. Jour. Cin. Soc. Nat. Hist., vol. v, p. 150; and 1890, Geol. Sur. Ill., vol. viii, pp. 336 and 369.

Comp. *Clonopora*, HALL, 1886. Pal. N. Y., vol. vi, p. 25; also, abstract Trans. Albany Inst., vol. x. p. 20, 1881.

Comp. *Entalophora*, LAMOUROUX, 1821. Exp. meth. des genres de pol., p. 81.

Zoaria ramose, slender, subcircular in cross-section. Zoœcia tubular, long, prismatic and thin-walled in the axial region, gradually diverging in all directions from an imaginary axis to the surface where they bend outward abruptly, often becoming free and much produced. Apertures circular, sometimes scattering, usually arranged in regular transverse or subspiral series.

Type: *M. cinctosum* Ulrich, Chazy (perhaps lower Birdseye) limestone of Kentucky.

Fuller investigations and comparisons with typical and authentic examples of *Entalophora* and *Clonopora* are necessary before we may be said to be in a position to decide permanently the merits of this genus. *Entalophora,* as now understood by Hincks and Waters, seems to me to be too comprehensive and might be, with advantage to classification, divided into at least two groups of generic rank, and it is not at all improbable that *Mitoclema* stands upon unoccupied ground. In the mean time no harm can result from the use of the name for these early paleozoic species.

MITOCLEMA(?) MUNDULUM *Ulrich.*

PLATE II, FIGS. 4-6.

Mitoclema ? mundulum ULRICH, 1890. Jour. Cin. Soc. Nat.Hist., vol. xii, p. 177.

Zoarium ramose, very small, the branches cylindrical, 0.5 or 0.6 mm. in diameter, with faint transverse striæ or wrinkles over the spaces between the zoœcial apertures. The latter are drawn out tube-like, about 0.15 mm. in diameter, and project strongly upward and outward from the surface of the small stems. Their arrangement is in rapidly ascending spiral series, with four or five in 2 mm. As near as can be determined from the material at hand, the zoœcial tubes diverge equally to all sides of the branches from an imaginary axis.

Owing to the absence of specimens suitable for slicing the internal characters of this species have not been determined. The generic position is therefore somewhat questionable, since it may prove to have the structure of *Diploclema* Ulrich (Geol. Sur. Ill., vol. viii, p. 368), founded upon *D. trentonense* Ulrich, a similar form occurring in the Trenton limestone of New York. In *Diploclema* the branches are slightly compressed, and the zoœcial apertures somewhat constricted and less prominent.*

Formation and locality.—Associated with the preceding in the topmost beds of the Trenton shales, at Cannon Falls, Minnesota.

Mus. Reg. No. 8103.

* In his paper on Wenlock shales Bryozoa Mr. Vine has described several similar species which he originally referred to *Spiropora* and later to *Entalophora*. Of these *S. regularis* is an unquestionable *Diploclema* and closely allied to our Niagara *D. sparsum* Hall, sp. The others I have not had an opportunity of examining.

Suborder CRYPTOSTOMATA, Vine.

Family RHINIDICTYONIDÆ, n. fam.

Stictoporidæ, ULRICH, 1890. Geol. Surv. Ill., vol. viii, p. 388.
Stictoporidæ (part.), ULRICH, 1882. Jour. Cin. Soc. Nat. Hist., vol. v, p. 152.

This name is proposed instead of *Stictoporidæ*, for the reason that the type genus is not, as I have heretofore held, properly expressed by the term *Stictopora.* Since Hall, the author of that name, and others, insist that *S. elegantula* is the type of *Stictopora*, it follows that the genus and family as described by me (*loc. cit.*) cannot stand. In my Illinois work, namely, I had taken the stand that *S. fenestrata* is to be regarded as the type, and as that species is unquestionably congeneric with *Rhinidictya*, Ulrich, (Jour. Cin. Soc. Nat. Hist., vol. v, p. 152), the latter was reduced to synonomy. Though the minute internal and external details of structure of *S. elegantula* have not yet been made public, enough is known of it to prove conclusively that it represents a genus to which *S. fenestrata* has no claim. This being the case, *Rhinidictya* will stand and include *fenestrata.**

Genus RHINIDICTYA, Ulrich.

Stictopora (part.), HALL, 1847. Pal. N. Y., vol. i, p. 73.
Stictopora, ULRICH, 1890. Geol. Surv. Ill., vol. viii, p. 388.
Rhinidictya, ULRICH, 1882. Jour. Cin. Soc. Nat. Hist., vol. v, p. 152; HALL, 1887, Pal. N. Y., vol. vi, p. 20.

"Zoaria composed of narrow, compressed, dichotomously divided branches, with the margins sharp, straight, and essentially parallel; attached to foreign bodies by a continuous expanded base. Zoœcial apertures subcircular or elliptical, arranged alternately in longitudinal series between slightly elevated, straight or flexuous ridges, carrying a crowded row of small blunt spines. Space immediately surrounding apertures sloping up to summits of ridges." (Geol. Surv. Ill., vol. viii, p. 388.)

Type: *R. nicholsoni* Ulrich, Birdseye Limestone, Kentucky.

This genus finds its strongest development numerically, both as regards species and individuals, in the rocks of the Trenton formation. The Minnesota shales of this group are especially rich in specimens, and so far as species are concerned, there is no other section of the country from which as many are known. Unfortunately, however, the various forms of the genus are not by any means easily distinguished from each other. It is true also that of those species which have a wide geographical range, as for instance from Minnesota to Kentucky and Tennessee, or to New

* For objections to the use of *Sulcopora*, d'Orb., instead of *Rhinidictya*, see Geol. Surv. Ill., vol. viii, pp. 683 and 687.

York and Canada, the specimens at each of these localities are marked by individual peculiarities, causing their identification to be, in some cases at least, unsatisfactory and generally rather difficult. Nothing less than monographical work can do the genus justice. Manifestly, even if possible in the present state of our knowledge, such work would be out of place here.

I shall therefore largely restrict my remarks to the Minnesota forms, while those occurring in other sections of the country will be mentioned incidentally only, and chiefly when comparisons are desirable.

RHINIDICTYA MUTABILIS *Ulrich.*

PLATE VI, FIGS. 1-6, 12-13; PLATE VII, FIGS. 10-23, and 25-28; and PLATE VIII, FIGS. 1-3.

Stictopora mutabilis (part.) ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 66.
Stictopora mutabilis, var. *minor* ULRICH. Ibidem, p. 67.

Zoarium a branching bifoliate stipe, varying considerably in width and superficial aspect.

Typical form :—In the commonest or typical form, the branches vary in width from 2.3 mm. to 3.2 mm., and in thickness from 0.7 mm. to 1.9 mm.; they divide dichotomously at intervals varying from 7 to 16 mm., but on an average a bifurcation takes place every 10 to 12 mm.; edges generally sharp, but with age become blunter as the stipes increase in thickness; non-celluliferous margins very scant, often practically wanting. Zoœcia arranged in from ten to eighteen rows; the usual number is fourteen or fifteen, but just beneath a bifurcation it generally exceeds twenty. Between the rows are straight longitudinal ridges, angular and crowned with a single series of small granules in well preserved young and average examples, thicker, rounded, and with stronger and more numerous granules in old examples (see plate VII, fig. 10). In young examples again the spaces between the ends of the apertures are slightly depressed, causing them (the apertures) to appear as openings in the bottom of shallow channels. In such specimens (see plate VII, fig. 15) the interspaces are comparatively thin and the zoœcial apertures correspondingly large, the long diameter of the latter being about 0.20 mm., and the short or transverse diameter about 0.12 mm. With age the transverse diameter may be reduced to less than 0.5 mm., while the channelled appearance becomes obsolete in the general thickening of the interspaces. In a few fragments, apparently representing the condition of extreme age, the zoœcial apertures are scarcely recognizable, the entire surface appearing as simply granulo-striate. In most cases the zoœcial apertures in one or more of the marginal rows are directed upward and outward. Measuring transversely, about eleven of the central rows in 2 mm. (extremes ten and twelve); longitudinally, about seventeen zoœcia in 5 mm. Except in a variety to be considered presently, the zoœcial apertures always appear as direct.

Vertical sections (plate VI, figs. 3 and 5) show that the zoœcial tubes, in their course from the basal (median) plate to the superficial aperture, form an angle of about 50 degrees with the surface. In the primitive portion of the zoœcia (*i. e.* that part which lies on each side close to the median laminæ) the posterior side curves outward and forward so as to form a curve about equaling one-fourth of a circle. The anterior extremity of the curve terminates abruptly at the primitive aperture ; from this point to the surface of the zoarium, or in what has been described as the "vestibular portion of the zoœcium," the course of the wall is nearly straight. In a few species of this genus (*e. g. R. fidelis* and *R. minima*) the junction between the "vestibule" and the curved posterior side of the "primitive cell", is prolonged into a short septum that I have designated as the "superior hemiseptum." In *R. mutabilis*, however, this septum is but little, if at all, developed, the junction being merely angular. When the section shows the transverse interspaces (this is often the case because of the great thickness of the interspaces in the vestibular region) they will be seen to exhibit interrupted dark vertical lines. These represent the tubular internal extensions of the minute granulations noticed at the surface. Stages in the growth of the zoarium may also be determinable. These are marked by dark lines, sharpest in the inner portions of the zoarium.

In transverse sections the chief point of interest is the row of minute tubuli that exists between the two parts of the duplex mesial lamina. (See plate VI, fig. 6.)

Tangential sections present a variety of appearances depending (1) upon the age of the fragments sectioned, and (2) the depth beneath the surface represented in the section. Using an old example the section may be made, with judicious manipulation, to show all the conditions through which the zoarium has passed, from the beginning of the zoœcia on the mesial laminæ to their mouths. Taking such a section, which, to be satisfactory, should not be less than 10 to 15 mm. long, the following features are likely to result: Starting with the mesial laminæ, which will be recognized as a faintly dark space, the first character worthy of notice are the "median tubuli." These are represented by very delicate parallel lines, longitudinal in the central third of the zoarium, but gradually diverging or curving toward its edges in the lateral thirds. Though not yet clearly demonstrated in this species, I nevertheless assume it to be a fact (because of observations in other forms possessing such tubuli) that the "mesial tubuli" connected with the minute tubes between the walls of the zoœcia, the surface extensions of which have been described as granules. (See plate VI, fig. 18.) Just above the mesial laminæ the section presents the basal or primitive portion of the zoœcia as sharply defined, thin-walled, oblong-quadrate spaces, the end walls of which, while approximately at right angles with the longitudinal lines at the center of the zoarium, gradually assume an oblique upward direction toward the sides. (Compare plate VI, fig. 13.) The next condition is when the anterior wall or side of the zoœcium becomes convex, while the posterior side begins to extend over the cell till at last the oval aperture is formed. Now the anterior and posterior walls are no longer recognizable in the section, but the division between the longitudinal walls is clearly marked by a dark line, that, when the preservation of the specimen is sufficiently favorable, will be noticed to consist of a connected series of minute tubuli. Besides these, an occasional dark spot or tubulum may be noticed in the end spaces. Most of the stages so far described are shown in fig. 13, on plate VI, and all further phases are to be classed as old conditions. They consist principally of an increase in the number of minute interstitial tubuli. (See plate VI, figs. 1 and 4.)

The above description does not include two forms that deserve recognition as varieties. Their peculiarities are not sufficiently constant to entitle them to the rank of species. In my preliminary report on the Minnesota Bryozoa (*loc. cit.*) another form of the species was separated as var. *minor*. The better and much more complete material since studied proves, however, that the specimens so designated are merely young examples and therefore not deserving of a distinct name.

Var. MAJOR *Ulrich.*

The zoarium in this variety is more robust, the branches being wider, in some cases attaining a width of over 8 mm.; usually the thickness is also greater, but thin examples are not uncommon. Perhaps the chief peculiarity of the variety is found in certain grano-striate or smooth spots, which occur at rather irregular intervals along the center of the branches. The internal structure agrees in all essential respects with that of the typical form of the species, the only feature not seen in the latter being the solid maculæ.

Mus. Reg. No. 5940.

Var. SENILIS, *n. var.*

PLATE VI, FIGS. 2 and 3; PLATE VII, FIGS. 16 and 17.

In this rather rare form the general appearance of the zoarium is like that of well developed examples of the typical variety. On comparison, however, it is found that the non-celluliferous margin is unusually wide and sharply defined. Connected with this are certain narrow, irregular or subelliptical, depressed spaces just within the axes of bifurcation. A more important peculiarity is presented by the zoœcial apertures. These, generally, instead of being placed in longitudinal furrows (as is usual in the genus), are oblique and inclosed by a strongly elevated peristome, highest at the posterior side. They manifest further a tendency to arrangement in transverse or diagonal rows. The result is quite unlike what is to be expected in *Rhinidictya*, and reminds one more of certain species of *Cystodictya*. Thin sections, however, demonstrate that this is merely a case of superficial resemblance and not of true relationship. On the contrary these prove, as is already clearly enough shown at the growing extremities of the branches, that we are dealing with a true *Rhinidictya* with affinities to *R. mutabilis* too close to admit of even specific distinction. Indeed, it is not improbable that the variety represents merely an unusual condition of senility. Still, the interior, as exhibited in the sections at hand, has one feature that may be accepted as corroborating my present estimation of the form.

Plate VI, fig. 2, represents a portion of a tangential section showing, besides one of the solid axillary maculæ, that the minute interstitial tubuli are exceedingly numerous, there being often three longitudinal rows between adjoining zoœcia. Figure 3 of the same plate presents a portion of a vertical section of the same specimen. This compares very nearly with figs. 5 and 12 (pl. VI) prepared from old examples of the typical form. The absence of horizontal lines in the lower part of the walls may be the result of imperfect preservation.

This species, especially in its typical form, is to be regarded as closely allied to *R. nicholsoni* Ulrich (Jour. Cin. Soc. Nat. Hist., vol. v, p. 170, pl. viii, figs. 6, 6a, 6b; 1882). Without taking into account certain slight though recognizable internal differences, that species is distinguished by its narrower, more strictly parallel, and less frequently bifurcating branches, the obliquity of its zoœcial apertures, and the lesser elevation and rigidity of the transverse interspaces. A nearer congener, perhaps, is the *R. basalis* (*Stictopora basalis* Ulrich, *op. cit.*, p. 169, plate viii, figs. 4 and 4a), but the very frequent bifurcation of the zoarium characterizing that species serves to distinguish them at a glance.* For comparisons with *R. trentonensis*, *R. fidelis*, and other species described in this report see under descriptions of each.

Formation and locality.—The typical form is extremely abundant in the middle and lower beds of the Trenton shales about Minneapolis and St. Paul, Minnesota. It occurs in these beds, but much less abundantly, also at Cannon Falls, Lanesboro, Fountain, Preston and other localities in the southern part of the state, and at Decorah, Iowa. The var. *major* is fairly abundant at the three localities first named, but the Cannon Falls specimens are less robust than usual. From the Galena shales at Cannon Falls, I have identified with the species something over forty fragments. In these, however, the zoœcial apertures are more oblique than usual. Respecting the Kentucky form, which I have heretofore referred to this species (14th Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 67, 1886), I prefer to await further investigations before expressing a conclusive opinion. This course seems the wisest also with respect to similiar forms from the Trenton rocks of Illinois, Tennessee, New York, Vermont and Canada.

Mus. Reg. Nos. 5938, 5939, 5941, 5956, 5957, 7597, 7599, 7606, 7621, 7663.

*A very good illustration of the necessity of thin sections for the determination of the generic relations of these bifoliate Bryozoa is furnished by my 1882 work on them in the publication cited. Had they been prepared of all the species therein defined, I would not have fallen into errors that now appear only too obvious. There I placed, for instance, *Pachydictya acuta* Hall, sp., *Cystodictya gilberti* Meek, sp., and *Rhinidictya basalis* under *Stictopora*, while *Rhinidictya* was founded, correctly enough, upon both external and internal peculiarities of *R. nicholsoni*. With sections I could scarcely have failed in determining the true position of these four species.

Rhinidictya paupera *Ulrich.*

PLATE V, FIGS. 19-21.

Stictopora paupera (part.) ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 69.

Zoarium usually less than 30 mm. high, consisting of narrow parallel-sided branches, dividing dichotomously at intervals of from 4.0 to 12 mm. Near the base the intervals are usually less than 6.0 mm., but further up the prevailing distance between bifurcations is about 8.0 or 9.0 mm. The width of the branches is fairly constant, deviating but little either way from 1.3 mm. Their thickness has not been noticed to exceed 0.5 mm. Zoœcia with nearly direct oblong apertures, their shapes varying with age from subquadrangular to elliptical. Interspaces rather narrow, or of moderate thickness. Zoœcial apertures usually in ten or eleven rows, but eight or nine and twelve rows often occur just after and before bifurcations. The central five or six rows are arranged between raised longitudinal lines, minutely granulose when perfect, while the two or three rows on each side are, besides being slightly larger than usual, directed obliquely outward. Five of the central rows in 0.7 or 0.8 mm; measuring lengthwise along same eighteen or nineteen apertures in 5.0 mm. Internal structure very much as in young examples of *R. mutabilis* Ulrich.

In the above diagnosis I have restricted my observations to the Minnesota form occurring in the upper division of the Trenton shales at St. Paul and Cannon Falls. This form should be regarded as the type of the species, and, pending further investigations, the wisest course seems to be to restrict the use of the name to it. The Kentucky and Tennessee form, occurring in the shaly upper member of the Trenton group in those states, which I have referred to this species (*loc. cit.*), is now regarded as distinct and next described as *R. neglecta.* I have two specimens from the "Phylloporina beds" at St. Paul that are exceedingly like, if not identical with the latter, but so far it has not been found in the shales above these beds, nor in the Galena limestone division of the Trenton in Minnesota. But several examples collected from the Galena shales at localities near Cannon Falls, seem to be identical with the Canadian form referred to *R. paupera* in 1886. A very fine example, with branches spread over a space 50 mm. wide by 75 mm. long, collected at Ottawa and kindly given to me by Mr. Walter R. Billings, causes me to doubt the strict propriety of that reference. This specimen shows that the Canadian form agrees with typical *R. paupera* in this, that the number of zoœcial apertures in 5 mm., measuring lengthwise, is eighteen to nineteen. Continuing our comparisons, however, we find the following differences: (1) the apertures are smaller and rounder, and have a more distinct peristome; (2) the interspaces on the whole are thicker, while the elevated lines enclosing the depressed quadrangular spaces in which the apertures are situated, are sharper; (3) the arrangement of the apertures between longitudinal lines prevails throughout, there being no oblique rows; and (4) while the width of the branches is about the same or greater (the average is very nearly 1.5 mm.); there are only seven to nine rows of cells instead of ten to twelve. In all these respects, however, the Canadian form agrees more closely with *R. neglecta*, but before I commit myself definitely upon the matter of their true relations I shall want to institute careful comparisons of their respective internal characters—a step that I am not yet prepared to make. Still, in the meantime, it may be desirable occasionally to refer to the Canadian form, in which case a distinctive appelation would be convenient. I propose, therefore, the provisional designation *Rhinidictya neglecta*, var. *canadensis*.

Comparing *R. paupera* (*sens. strict.*) with other species of the genus, we find that it is distinguished from *R. mutabilis* by its smaller zoarium, narrow and more frequently dividing branches, more numerous zoœcia in a given space, and the greater differentiation in the direction of the central and marginal zoœcial apertures; from *R. trentonensis* and *R. nicholsoni* in much the same features, though in a different degree. To them is to be added, for the former, that its zoœcial apertures are not only much larger, but more nearly quadrate or hexagonal, with the longitudinal ridges between them nearly or quite obsolete; and for the latter, that its zoœcial apertures are more oblique. *R. exigua* is very close, differing mainly in its narrower branches and less oblique arrangement of its zoœcial apertures in the marginal rows. *R. minima* has thicker and more ornamental zoœcial interspaces, and differs internally in having the superior hemiseptum well developed.

Formation and locality.—Not uncommon in the upper third ("Phylloporina beds") of the Trenton shales, at St. Paul and south of Cannon Falls, Minnesota, and Decorah, Iowa. Probably also in the Galena at Neenah, Wisconsin.

Mus. Reg. Nos. 5935, 7564, 7612.

Rhinidictya neglecta, *n. sp.*

PLATE V, FIGS. 22-25.

Stictopora paupera (part.) Ulrich, 1886. Fourteenth Ann. Rept. Geol. Nat. Hist. Sur. Minn., p. 69.

Zoarium small, branches dividing dichotomously at intervals of from 4 to 7 mm., rather convex, the margins parallel, not very sharp, and with the non-celluliferous border variable. Width of branches rather constant at about 1.5 mm. Zoœcia in eight to eleven ranges, the usual number nine, with rather small, elliptical; oblique apertures, about seventeen in 5 mm. lengthwise, and 6 in 1 mm. transversely. In most cases all the apertures are directed longitudinally or parallel with the edges of the branches; in others, however, those forming the marginal row on each side may be turned slightly outward. Interspaces comparatively thick, less ridge-shaped than usual, often slightly zigzag, with the range of granules well developed.

Internal structure chiefly diagnostic in vertical sections. These show that the primitive or prostrate cell is comparatively elongate, and that at the turn into the "vestibule" the wall is merely sharply curved and not angular, as in *R. mutabilis*.

Associated with this species is a larger form, agreeing in all other respects quite closely with it. At first I thought it identical with *R. mutabilis*, and so figured it in 1890 (Ill. Geol. Surv. Repts., vol. viii, p. 304, fig. 2, d, f, and g). At present I should prefer regarding it as a variety of *R. neglecta*. For the Canadian variety of this species see remarks under *R. paupera*.

Compared with other species, *R. nicholsoni* will be found to have grown differently, the bifurcation of the branches being much less frequent; the zoœcial apertures are also more oblique, and vertical sections quite different.. *R. mutabilis* has wider branches, more direct zoœcial apertures, and different vertical section.

Formation and locality.—Not uncommon in strata equivalent to the Galena limestone of the Northwest, at Frankfort, Kentucky, and several localities in Boyle and Mercer counties of that state. Also in rocks of the same age at Nashville, Tennessee. Two fragments supposed to be identical with these Kentucky and Tennessee specimens were collected at St. Paul from the upper shales.

Mus. Reg. No. 8104.

RHINIDICTYA EXIGUA *Ulrich.*

PLATE VIII, FIGS. 6-10.

Rhinidictya exigua ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 184, fig. 9.

Zoarium bifoliate, small, growing from an expanded basal attachment. Lower portion of branches subcylindrical, with the zoœcial apertures here largely filled with a smooth solid deposit of sclerenchyma. Above the first bifurcation the branches have become acutely elliptical in cross-section, their width varying from 0.5 mm. to 1.2 mm., with parallel margins, the edges sharp, but in no case seeming to have more than just an appreciable non-celluliferous border. Zoœcia in from three to seven rows on each face, their apertures, in the usual state of preservation, appearing as impressed, nearly direct, subelliptical or subquadrate, those in the central rows 0.2 mm. long by 0.1 mm. wide, those in the marginal row on each side of the branch sometimes a little larger and often directed somewhat obliquely outward; all regularly arranged longitudinally, seventeen or eighteen in 5 mm., and separated from each other by rather thin, seemingly smooth interspaces, the latter forming slightly elevated longitudinal ridges. In the specimens originally described and figured, the apertures are somewhat obscured by remains of the shaly matrix, but with several fragments lately discovered among my material from Fountain, Minn., this is not the case. The latter are also exceptionally well preserved and show that the apertures are really rather strongly oblique, with a slight "lip" at the posterior border. Not in these specimens, even, have I detected satisfactory evidence of the presence of the row of granules on the longitudinal ridges usual in species of this genus. Yet, as is shown by thin sections, the minute inter-zoœcial tubuli, whose superficial extension forms the granules, are developed in the usual manner.

The obliquity of the zoœcial apertures allies this species to the larger *R. nicholsoni*, but not closely enough to cause confusion between them. The zoœcia are larger in that species, there being thirteen to fifteen where we have seventeen to eighteen in this form. It also resembles *R. paupera* and *R. minima*, but they are distinguished: the first by having more ranges of zoœcia with the apertures in several of the marginal rows on each side of the branches oblique; the second by its smaller zoœcial apertures and much wider granulo-striate interspaces.

Formation and locality.—Comparatively rare in the lower third of the Trenton shales at Minneapolis, St. Paul and near Fountain, Minnesota.

Rhinidictya minima *Ulrich.*

PLATE V, FIGS. 13-18.

Rhinidictya minima Ulrich, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 183, fig. 8.

Zoarium small, branches 0.8 to 1.2 mm. wide, commonly 1.0 mm., bifurcating at intervals of 2 or 3 mm. Zoœcia in five or six longitudinal rows, increasing to seven, eight, or nine before bifurcation takes place; sixteen in 5 mm. lengthwise. Size and shape of apertures, and character of interspaces, varying with age. The enlarged figures on plate V represent the usual appearance of the oldest examples. In these the zoœcial apertures are small and narrow-elliptical (about 0.11 mm. by 0.06 mm.) and the interspaces very wide, with the granulose ridges projecting but little above the level of the peristomes surrounding the apertures. Under a glass of low power the interspaces appear as rather flattened, and marked with straight or slightly flexuous longitudinal striæ. Under a higher power the striæ resolve into rows of small papillæ, with one continuous series, a little stronger than the others, separating the apertures into longitudinal rows, and one or two short series in the slightly depressed spaces between the ends of the apertures. When in a good state of preservation, a row of granules, rather smaller than the others, is found to crown the peristomes as well. These were overlooked in drawing fig. 15. In younger examples the principal longitudinal ridges are relatively higher, causing the zoœcial apertures, which in these cases are wider, and the intermediate spaces to appear as set in shallow channels. Not infrequently the peristomes of succeeding zoœcial apertures are connected in a manner causing the transverse interspaces to appear as bearing three longitudinal striæ or rows of granules. Margin of branches acute, the non-celluliferous band rather wide and occupied by one or more lines of papillæ.

Of internal characters it will suffice to mention that there is a well-developed superior hemiseptum, and a greater number of median tubuli in the end spaces between the zoœcial apertures (see fig. 18) than in any other species known to me.

This pretty little species is not likely to be confounded with any of the preceding, unless it be with *R. exigua*. But the surface characters, especially when well preserved, are so very dissimilar that confusion, even in that case, is inexcusable.

Var. MODESTA *n. var.*

PLATE V, FIG. 17.

Under this subordinate name I propose provisionally to classify an associated form, differing in some respects constantly from the typical variety. Both are represented by numerous specimens, with no question in any case as to where each belongs. They agree, however, too closely in the more important elements of structure to admit of specific separation. Except in the case of subsequent discoveries in other regions proving the supposed new variety to hold its own geographically, the above degree of separation seems to me sufficient. My studies of the paleozoic bifoliate Bryozoa have taught me to distrust mere deviations in the width of the branches as being good specific characters.

In the variety the branches are wider, the width varying from 1.7 mm to 3.0 mm., the zoœcial apertures larger, and the interspaces correspondingly narrower. Still, the number of apertures in 5 mm., measuring lengthwise, is, as in the typical form, about sixteen. In the best preserved specimens the superficial characters resemble those of young examples of typical *minima* very closely, the chief difference being that the zoœcial apertures, as already stated, are larger, and the non-poriferous band generally wider and grano-striated obliquely instead of longitudinally. The striæ also project slightly beyond the edge. causing the latter to be minutely serrate.

When the drawings for this species were prepared I possessed, unfortunately, only a few specimens. The number was subsequently greatly increased by pickings from washings of shales from the original locality, kindly sent me by Mr. W. H. Scofield, of Cannon Falls.

Formation and locality.—Galena shales, near Cannon Falls, Minnesota; associated with species of *Nematopora, Arthropora armatum, Diastoporina flabellata*, and other small Bryozoa characterizing the horizon.

Mus. Reg. No. 8105. Var. *modesta*, 8106.

RHINIDICTYA FIDELIS *Ulrich.*

PLATE VI, FIGS. 7, 7a, 7b AND 8.

Stictopora fidelis (part), ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 68.

To save repetition it will suffice to say of the external characters of this species that they are exceedingly like those of the next described *R. trentonensis*, a slightly greater width of the also more nearly quadrangular zoœcial apertures, being rather inconspicuous differences.

In tangential sections the deepest parts show the prostrate portion of the zoœcia lying on each side of the mesial laminæ. The latter themselves may be shown as in fig. 7b with the inclosed "median tubuli." These horozontial tubuli seem to connect with the vertical sets that form series separating the rows of zoœcia. At first the zoœcia appear as simple quadrangular spaces, their width equalling about half of the length. In the next stage these spaces are divided by a line, transversely in the central rows, and obliquely upward in the marginal ranges. This line represents the incurving superior hemiseptum, which is developed to an unusual degree in this species. In the stage immediately succeeding, the posterior half is covered, while the open anterior part is gradually reduced in width till it assumes the elliptical shape commonly presented by the "vestibular" portion of the zoœcia. From now on to the surface, the distance depending upon the age of the specimen, the section exhibits little if anything to distinguish it from similar sections of other species. There are rows of subelliptical apertures separated by thick interspaces, and between the rows a dark, faintly flexuous line, which, when carefully examined, is found to contain a series of minute pores.

Vertical sections are highly characteristic, especially when they have been carefully prepared and show the primitive region of the zoœcia in a satisfactory manner. The anterior side of the zoœcial cavity is almost straight from the mesial lamina to the superficial aperture. The posterior and upper side is concave and the curve produced in front into a strongly developed hemiseptum, projecting over half the distance toward the base of the anterior wall. An occasional complete diaphragm-like structure may be detected crossing the tubular vestibule. All of these characters are shown very well in fig. 8.

As has been stated, it is not an easy matter to distinguish this species, by means of external characters alone, from *R. trentonensis*, and until the observer has become thoroughly familiar with the various forms of this genus occurring in the Minnesota rocks, he is cautioned to secure the evidence of thin sections before he places much confidence in his identification, of this species, at any rate. The strongly developed superior hemiseptum will distinguish the sections at once from those of all other species except *R. minima*. That species occurs at a higher horizon (Galena shales), grew differently, has smaller elliptical zoœcial apertures and much thicker, as well as quite differently marked interspaces.

Formation and locality.—Rare in the lower third of the Trenton shales at Minneapolis, Minnesota. *Mus. Reg.* Nos. 5936, 5937.

Rhinidictya trentonensis *Ulrich.*

PLATE VI, FIGS. 14-18; PLATE VII, FIGS. 6-9.

Dicranopora trentonensis Ulrich, 1882. "Amer. Pal. Bry.," Jour. Cin. Soc, Nat. Hist., vol. v, p. 160, pl. 6, figs. 15, 15a.
Stictopora fidelis (part.) Ulrich, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 68.

Zoarium branching dichotomously at intervals of from 8 to 20 mm. Branches 2 mm., or a little less, wide, sharp-edged, the non-poriferous margin very narrow Zoœcia in from eight to eleven ranges, nine or ten the commonest numbers. Apertures nearly direct, comparatively large, of elliptical, subquadrate or hexagonal form, with sixteen, rarel yseventeen, in 5 mm. longitudinally, and five in 1 mm. transversely; those forming the marginal row usually a little larger than the average and directed slightly outward. Interspaces thin, apparently without granules, the longitudinal ones but little, if at all, elevated over those running transversely, the former generally a little zigzag in their course.

In tangential sections dividing the zoarium just beneath the surface, the interspaces are moderately thick, and contain a line of very minute pores running lengthwise between the rows of cells. Here the zoœcia, or rather their "vestibular" portions, are elongate-elliptical, but at a deeper level, where the section cuts down into the primitive portion of the zoarium, they have the usual oblong-quadrate, or subrhomboidal shape. In one of the sections showing this region (see pl. VI, fig. 18) a row of "median tubuli" is distinctly visible in the transverse partitions.

Vertical sections remind us much of *R. nicholsoni* and *R. grandis*, in this, that the interspaces or walls are rather thin, and that there is not even a sign of a superior hemiseptum at the base of the "vestibule," the walls being merely thickened a little abruptly. In sections of thick examples a complete diaphragm may cross the tubes. In such cases it is common to find each half of the zoarium, in part at least, to consist of two superimposed layers of cells.

A re-examination of the Tennessee type of this species has shown conclusively that it is not a *Dicranopora* but a *Rhinidictya*, with relations to *R. nicholsoni* and *R. grandis*, its systematic position being nearly intermediate between them. From the first of those species it differs mainly in its wider and nearly direct zoœcial apertures and narrow interspaces, these being also without surface granulations so far as observed. Still, some of the Minnesota specimens referred here resemble *R. nicholsoni* more closely than do the Tennessee types. It is therefore not improbable that more detailed comparisons than I have found time to make may show that, as I believed in 1886, *R. nicholsoni* also is represented in the Minnesota strata. *R. grandis* is readily distinguished by its wider branches and larger cells. *R. pediculata* likewise seems closely related, but its peculiar growth and somewhat wider branches will, it is believed, serve to separate them. Lastly, *R. fidelis* so closely resembles this species in its *external* characters that I am at a loss to point out really serviceable distinguishing features. As a rule the zoœcial apertures of *R. trentonensis* are a trifle narrower and less often of quadrate shape. Comparing their internal characters, we at once notice a decided difference in the inner part of the zoœcia where that species presents a well developed superior hemiseptum. This is a point of such importance that I am obliged to view the two species as widely distinct.

Formation and locality.—"Glade" limestone (Birdseye) at Lebanon, Tennessee; lower third of Trenton shales at Minneapolis, Minnesota. Rather rare. It has also been collected by Mr. C. Schuchert in the "Lower Blue beds" at Janesville, Wisconsin, and Rockton, Illinois.

Mus. Reg. Nos. 7549, 7560.

RHINIDICTYA GRANDIS *n. sp.*

PLATE V, FIGS. 11 and 12; PLATE VI, FIGS. 19 and 20.

Zoarium bifolate, large, branchy, the branches flattened, 2.5 to 3.5 mm. wide, the edges obtuse, with the non-poriferous margin of moderate width. Zoœcia in from eleven to fifteen alternating rows, with large, almost direct, slightly oblong, hexagonal apertures, fourteen or fifteen in 5 mm. longitudinally, and nine of the central rows in 2 mm. transversely. Interspaces thin, without papillæ, ridge-shaped, sloping down into the apertures from the summit, the latter reaching to about the same level in both the cross and longitudinal partitions. In conforming with the hexagonal shape and alternate arrangement of the zoœcial apertures, the longitudinal walls usually take a decidedly zigzag direction. In the marginal rows the apertures are commonly more or less irregular in shape, size and arrangement. An occasional small cell may be noticed.

In vertical sections the comparative erectness of the zoœcia is to be noticed; also the shape of the walls. These show no sign of a superior hemiseptum, though a slight angularity is often perceptible at the turn into the vestibular region.

Tangential sections give a good idea of the unusual size of the zoœcia. When the section cuts deeply the prostrate portion of the cells is shown. Here they have the usual characters—thin walls, the longitudinal ones straight, the transverse ones at right angles to them in two or three of the central rows, and directed obliquely upward in the lateral series, the obliquity increasing with each successive row. Just beneath the surface the apertures are elliptical, with a faint line about them, while a series of exceedingly minute dots, or a fine double line instead, passes longitudinally through the interspaces.

The large size of the zoœcial apertures distinguishes this species from all others of the genus known to me. Their hexagonal shape, and the absence of longitudinal ridges are two more features that may be relied on in separating it from such species as *R. mutabilis*, *R. nicholsoni*, *R. fidelis* and *R. neglecta*, but *R. pediculata* and *R. trentonensis* approach it in these respects. The last is, I believe, its nearest congener, but is distinguished readily enough by its narrower branches and smaller zoœcia.

Formation and locality.—The types are from the Birdseye horizon of the Trenton formation at Dixon, Illinois. Other examples were noticed in Wisconsin material collected for the State Museum by Mr. Charles Schuchert and sent me for identification. All the specimens are from the "Lower Blue Beds" of the Wisconsin geologists, in which the species is sometimes associated with *R. trentonensis*. Mr. Schuchert's localities are near Beloit, Mineral Point and Janesville.

Mus. Reg. Nos. *7548*, *7554*, *7593*, *7594*.

Rhinidictya pediculata *n. sp.*

PLATE VII, FIGS. 1-5.

Zoarium bifoliate, apparently growing to but little more than 25 mm. in hight. It begins with a small expansion, by means of which it was evidently attached to foreign bodies. Arising from this is a small and short, rounded, subsolid and striated footstalk, that soon flattens and spreads into rapidly bifurcating branches, all spreading approximately in the same plane. The branches have an average width of about 3.0 mm., are very thin, with unusually sharp edges, wide and obliquely striated non-poriferous margin.* Zoœcia in from eleven to fourteen ranges, the usual number twelve, with the outer row on each side irregular in their arrangement, larger than the average, and directed obliquely outward. In the central rows the apertures are commonly elliptical, or subangular, and sunken into oblong hexagonal spaces, bounded by thin walls, of which the lateral ones form slightly zigzag, low ridges. The last feature, however, is to be seen only in the best preserved examples, those in the usual condition seeming to have the interspaces rising to the same level on all sides of the aperture. Measuring lengthwise along the central ranges fifteen or sixteen

*The latter is not shown in fig. 5, (pl. VII) the drawing having been made from a weathered example.

zoœcial apertures are to be counted in 5 mm., while twelve rows occur on a branch 3.0 mm. wide, on which the non-poriferous borders occupy space amply sufficient to accommodate another row on each side.

Internal characters not observed, the process of fossilization having been too unfavorable to preserve the minuter details of structure.

The small footstalk, rapid spreading of the zoarium, and the wide marginal space, are the characters relied upon in distinguishing this species. In other respects the species is very near *R. trentonensis* and *R. grandis.*

Formation and locality.—All the specimens seen were collected by the author from the lower limestone of the Trenton formation, at Minneapolis, Minnesota.

Mus. Reg. No. ?5934.

Genus EURYDICTYA, Ulrich.

Eurydictya, ULRICH, 1889. Miller's N. Amer. Geol. and Pal., p. 301; 1890, Geol. Surv. Ill., vol. viii, pp. 389 and 520.

Zoaria bifoliate, consisting of broad, simple or irregularly divided expansions, the surfaces of which exhibit more or less conspicuous, though usually small, maculæ or monticules. Zoœcia of the same type as in *Rhinidictya.*

Type: *E. montifera* Ulrich, 1890. Geol, Surv. Ill., vol. viii, p. 521.

This genus was established for the reception of a small group of Lower Silurian species that, though intimately related to *Rhinidictya*, Ulrich, it seemed desirable to distinguish from that genus. The broad and undefined zoarial expansion pertaining to the several species gives them a very different aspect from that presented by the narow, parallel-margined, and regularly branching stipes so strictly adhered to by all the true species of *Rhinidictya.* That intermediate forms occur is true, nor can we doubt that the dividing line between the two genera will continually grow more shadowy with the discovery of new species. But, as that difficulty is encountered by the systematist throughout all organic nature, it cannot be regarded as a bar to the formation of generic groups, because, theoretically, if the course were carried to its logical conclusion, all necessity for classification would cease. Some recognition of obvious departures from a type is necessary, and in the present incompleteness of our knowledge the only satisfactory plan to accomplish this is to adhere strictly to the binomial nomenclature. In this declaration I am to be understood as aiming at subgeneric rather than varietal designations.

Eurydictya multipora (?Hall's sp.), the only species of the genus so far known to occur in Minnesota, is the least typical of the genus. In shape and structure of its end walls the species approaches *Phyllodictya varia.* The type of the genus, *E. montifera,* may be looked for in the upper beds of the Hudson River group in Fillmore and other counties in the southern part of Minnesota where that horizon is exposed.

EURYDICTYA MULTIPORA ? *Hall*, sp.

PLATE VI, FIGS. 9-11; PLATE VII, FIGS. 24 and 29-31; PLATE XIV, FIGS. 9-11.

? *Phænopora multipora* HALL, 1851. Geo. Lake Sup. Land Dist., vol. ii, p. 206.
Phænopora (?) *multipora* ULRICH, 1882. Jour. Cin. Soc. Nat. Hist., vol. v, p. 171.
Eurydictya multipora ULRICH, 1890. Geol. Surv. Ill., vol. viii, p. 520. (Referred to new genus only.)

Zoarium forming irregularly divided wide fronds, 6 to 20 mm. in width, or simple undulating expansions, or a combination of the two. The Minnesota example figured on plate XIV is a fragment of a slightly undulating expansion, 0.7 mm. to 1.5 mm. thick, that must have been no less than 20 mm. wide. The others are of less width, and one (plate VII, fig. 24) deviates so widely from the ordinary growth that it was at first believed to belong to *Rhinidictya mutabilis* var. *major*.

Surface with irregularly distributed small maculæ, often very inconspicuous and scarcely interrupting the regularity of the longitudinal ridges. In other cases they may appear as smooth solid spots, fully 1 mm. in diameter. As a rule they give one the impression of a variable number of elongate zoœcia filled with a solid deposit of calcareous material. Zoœcial apertures subelliptical, more or less oblique, (generally more so than in fig. 11, plate XIV) with a slight peristone, strongest at the posterior margin, arranged between rather prominent, granulose, longitudinal ridges, seventeen or eighteen in 5 mm.; also in curved diagonal series, but these are never very regular and frequently turn into transverse rows. Measuring transversely, from twenty-three to twenty-six of the longitudinal rows may be counted in 5 mm. The width of the interspaces is usually about equal to the diameter of the apertures. When the latter are partially filled with the clayey maxtrix, they may appear as of subquadrate shape, with the interspaces thinner than usual. In the narrow or basal part of the fronds, the spreading edges are sharp, non-poriferous, and striato-granulose, while several of the marginal rows of the zoœcial apertures may be directed obliquely outward.

Vertical sections show that the primitive cell is rather high, short, and has thin walls. These curve over it to a point marking the beginning of the vestibular portion of the tube, when they bend sharply outward. At the same time the interspaces (walls) are greatly widened, and three to five shallow vesicles are developed in direct sequence. Above these the interspaces are solid and seemingly structureless, if we except a dark line running lengthwise through them. No diaphragms observed.

Tangential sections may present one or all of three distinct phases or stages in the development of the zoarium. Their exhibition depends upon the distance from the median laminæ at which the zoœcia are cut by the section. In the first or deepest part of the section, the zoœcia are quadrate, thin-walled, and arranged in regular rows between longitudinal plates. The end or transverse partitions appear less sharp than the longitudinal lines, are generally a little curved, and cross the spaces at either a right angle to the direction of the growth, or somewhat obliquely. In the latter case the primitive cell is subrhomboidal in shape. In the succeeding stage we see the structure immediately following the formation of the original aperture, *i. e.*, the beginning or lower part of the vestibular portion of the zoarium. Now the zoœcial cavity is rounded, of elliptical shape, with a thin ring-like wall, generally in contact with the longitudinal plates. The latter appear usually as dark structureless lines separating the rows of cells. The end spaces, in part at least, may be empty (*i. e.*, filled with clear calcite) thus indicating the presence of interstitial vesicles. In the third or superficial stage, the interstitial vesicles have been filled with solid tissue and the diameter of the zoœcial cavities generally reduced a little by a thin internal deposit, while the dark longitudinal lines are now clearly resolvable each into a crowded row of exceedingly minute tubuli.

Some of the St. Paul specimens look very much like wide examples of the large variety of *Rhinidictya mutabilis*, but after one becomes familiar with the peculiarities of each, it is not difficult to distinguish them. In the first place the zoaria of the var. *major* have always an aged appearance, being heavy, with subparallel, rounded edges, thick interspaces, and correspondingly narrow zoœcial apertures. The small specimens of *E. multipora*, on the contrary, are thin, sharp-edged, oftener and more irregularly divided, and with comparatively thin interspaces. When we compare thin sections the differences are as shown on plate VI, by figs. 1 and 9, 6 and 10, and 11 and 12.

Both *E. calhounensis* Ulrich, and *E. montifera* Ulrich, have a well developed superior hemiseptum, but no interstitial vesicles. In other respects the first is rather closely simulated by the present species. There is no associated species with which *E. multipora* is likely to be confounded. The *Rhinidictya* var. *major* is not found, as far as known, so high in the shales, being restricted apparently, like *Phyllodictya varia*, another wide bifoliate form, to the middle division of the Trenton shales.

This species, as above cited, was described by me from Kentucky specimens. Since then I have found it in Tennessee, and in 1885 a single example in the Minnesota State collection proved to belong to the same species. Two years later Mr. Schuchert and the writer secured about ten specimens at St. Paul.* Respecting the specific identity of all these specimens with the originals of Hall's *Phænopora multipora*, I should say, that I am still of the opinion expressed in 1882, but having since

*During the past two weeks (to April 10th, 1892,) the writer secured no less than fifty specimens at St. Paul.

then learned to esteem caution, the present less positive stand on the question will suffice till we have been informed of the minute structure of Hall's types. These were derived from the northern part of Wisconsin, and if they prove to be identical with the specimens here described, a considerable extension of the geographical range of the species will result. The species is an important one too, in being highly characteristic of one horizon.

Formation and locality.—In Minnesota known only from the upper third of the Trenton shales, at St. Paul. In Kentucky, rather common in the shales above the "Modiolopsis beds." In Tennessee it holds the same horizon (Safford's Middle Nashville Series) at Nashville.

Mus. Reg. No. 5942.

Genus PHYLLODICTYA, Ulrich.

Phyllodictya, ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 153; MILLER, 1889, North Amer. Geol. and Pal., p. 315; ULRICH, 1890, Geol. Surv. Ill., vol. viii, p. 390.

Zoaria bifoliate, simple or iregularly branched, growing from an expanded basal attachment. Zoœcial tubes long, with complete diaphragms but no hemisepta; from the central axis they bend outward very gradually, causing the apertures to be more or less strongly oblique, with the posterior edge raised lip-like. Interspaces wide, subsolid, transversed vertically by one or two rows of minute tubuli, which appear as so many papillæ at the surface.

Type: *P. frondosa* Ulrich.

This genus requires more study before the relations to *Eurydictya* on the one side, and *Pachydictya* on the other, can be determined and satisfactorily established. The questions involved are rendered difficult of solution by the commingling of characters found in *Pachydictya splendens* Ulrich. and *P. firma* Ulrich, of the upper beds of the Hudson River group, and *Eurydictya multipora* (? Hall) of the Trenton group. All three of these species have certain features in common that do not pertain to the more typical forms of either *Pachydictya* or *Eurydictya*. It is, however, precisely in those characters that these species remind us of *Phyllodictya*.* Though having an abundance of specimens of, at any rate the majority of the species, bearing directly upon the points at issue, I have been obliged, chiefly because of a lack of time, to defer pushing my investigations to a satisfactory conclusion. I realized also that all partial studies of the group of bifoliate Bryozoa, and consequent rearrangements of species, are only too likely to prove premature and faulty when the full results of a complete study of the group shall have become available. For the present it is sufficient to point out the obscure and perhaps weak spots in the classification now in use.

*Another genus presenting points of agreement with *Phyllodictya* is *Ptilotrypa* Ulrich, founded upon a single species from the upper beds of the Hudson River group. But the absence of "median tubuli" in the latter is a difference of such importance that the two genera must be regarded as widely distinct and as belonging to different families.

PHYLLODICTYA FRONDOSA ? *Ulrich.*

(Not figured.)

Phyllodictya frondosa ULRICH, 1882. Jour. Cin. Soc. Nat. Hist., vol. v, p. 174, pl. 8, figs. 11, 11a and 11b.

The name of this species occurs in the list appended to my preliminary report on the Minnesota Bryozoa (Fourteenth Ann. Rep. Geol. Surv. Minn., p. 102; 1886). The identification was based upon several small fragments, none of them in a condition to afford satisfactory thin sections. Nor did any of the more numerous and larger specimens of *Phyllodictya* collected subsequently for my own cabinet by Mr. Charles Schuchert and others, as well as by myself, prove any better for that purpose. I was, therefore, unable to verify the identification until last year, when I detected a single well preserved fragment, about 15 mm. square, in a lot of fossils kindly given me by Prof. C. W. Hall, of the State University. Both the superficial and internal structure of this specimen, which was obtained too late to appear on the plates, agrees closely enough with that of one of the original Kentucky types of the species. Ordinarily, this would be quite sufficient to establish the identification of a species, but in this case, a fact about to be mentioned causes me to use the question marks. Recently I had occasion to prepare a set of thin sections of a specimen supposed to belong to this species. These seem to differ so much from the original set, that one of two things is evident: either I included two species in my original diagnosis of *P. frondosa*, or the species is more variable in its internal structure than I supposed. It is probable that the differences observed are only the result of age, but as I have not had time to make the sections necessary to prove this, I thought it best to mention the difficulty, leaving its removal to some future time. Before giving the following brief description of the Minnesota specimens, it would be well to mention that the one received from Prof. Hall agrees best with the specimen represented by fig. 11 of the original work on the species, while the resemblance to the specimen that furnished the original thin sections and the enlarged surface view is much less.* Also, that I now believe that none of the specimens catalogued by me in 1886 as *P. frondosa* really belong there. Most of them, perhaps all, are to be referred to the new species *P. varia.*

Zoarium leaf-like, 1.5 mm. thick; size unknown, only fragments having been seen. At intervals of 3 or 4 mm. the surface presents smooth or grano-striate solid spots, 1 mm. or more in diameter. These spots may be on a level with the general plane of the surface, or slightly depressed. Zoœcial apertures ovate, a little

*The new set of sections were prepared from an example like the first.

drawn out anteriorly, with the posterior edge abrupt and slightly elevated, arranged in straight or curved, diagonally intersecting lines, and, less obviously, in longitudinal series, with about seventeen in the former and twelve in the latter in 5 mm. Interspaces separating the apertures in the diagonal rows narrower than the apertures, while those between their ends may be wider and concave instead of rounded, with the posterior rim extending up along their sides. When in a good state of preservation a row of minute papillæ crowns this rim, and thus extends around the posterior margin of the zoœcial apertures and up their sides to the row belonging to the succeeding aperture. There are therefore two rows of these papillæ between neighboring apertures, but it is not uncommon to find the spaces between the apertures in the diagonal rows too narrow for their full development, and then they are crowded into an irregular single row.

In vertical sections the zoœcial tubes begin with a rather long prostrate cell from which they proceed to the surface by a gentle outward curve; the continuance of this curve causes the apertural portion of the tube in old examples to be much more nearly direct to the surface than in their younger stages. In an average example a line drawn from the aperture to the proximal extremity of a tube forms an angle of about 35 degrees with the central laminæ. Complete diaphragms to the number of five have been observed to cross each tube. Near the central axis the walls are thin, but soon they begin to spread, admitting of the intercalation of from three to five successive vesicles. Above these the interspaces are filled with solid matter, seemingly structureless except for the minute dark tubuli traversing them in a direction at right angles to the plane of the zoarium. These tubuli arise in a dark line running along the posterior side of the tube.

Tangential sections show a considerable deposit of solid material on the inner side of the tubes. This is scarcely to be described as ring-like, since it is not sharply defined nor of equal thickness all around, being widest and rather indistinct anteriorly, and but illy distinguished at any point from the interspaces. The latter are occupied by minute dark spots (median tubuli) in single or double rows, representing and corresponding with the arrangement of the minute superficial papillæ described.

The above description is based almost entirely upon the specimen mentioned as having been received from Prof. C. W. Hall. Its characters, as has been stated, agree very closely with one type of *P. frondosa*, but not nearly as well with the other, possibly distinct form, originally united with it. Compared with *P. varia*, to which I shall provisionally refer nearly all of the Minnesota specimens of *Phyllodictya* so far seen, it will be found to differ in having thinner interspaces, and larger apertures, with the diagonal instead of the longitudinal arrangement predominating. Further differences are to be found in the character of the interspaces, and in the shape of the zoarium.

Formation and locality.—Rare in the Trenton shales, at Minneapolis, Minnesota. The types of the species are from the Birdseye limestone at High Bridge, Kentucky.

PHYLLODICTYA VARIA, *n. sp.*

PLATE XIV, FIGS. 1-8.

Comp. *Stictopora labyrinthica* HALL, 1847. Pal. N. Y., vol. i, p. 50.

Zoarium variable, consisting of broad, leaf-like, thin expansions, either simple or with irregular marginal incisions, or of wide branching fronds, with the edges subparallel, sharp, and non-poriferous. At intervals of about 4 mm. the surface exhibits subsolid, even or slightly depressed spots or "maculæ," smooth when worn, finely grano-striate as well as faintly channeled longitudinally when well preserved. In the youngest examples these maculæ are small and sometimes scarcely distinguishable, but with age they seem to increase in size (compare figs. 2 and 7). The most obvious and normal arrangement of the zoœcial apertures is in longitudinal series, twelve or thirteen in 5 mm., between delicate papillose ridges; but the general aspect of the surface varies greatly in the specimens before me. Some of these differences are doubtlessly due to, or exaggerated, by weathering and other accidental causes, yet others are as clearly changes consequent upon increasing age, and thus are to be regarded as expressing different stages in the development of the zoarium. In the youngest the zoœcial apertures are very oblique, with a rim, strongly elevated at the posterior side, and dying out at the sides or seeming to unite with the delicate ridges separating the rows. This condition is represented in figs. 2 and 3. In later stages the longitudinal ridges becomes indistinct, the interspaces flatter, the posterior "lip" less pronounced, the apertures less oblique and, sometimes, a little smaller, while in other cases, probably representing a weathered condition, they appear larger, with the interspaces rounded. The longitudinal arrangement also becomes less obvious but never, so far as observed, quite subordinate to the diagonal. This may seem to have occurred over limited spots, especially when the maculæ are unusually large as in the specimen represented by figs. 6 and 7.

Only one specimen proved suitable for sectioning. This even failed to preserve the minuter details of structure as well as was desired. So far as the internal characters could be made out they are shown in figs. 4 and 5, excepting that by an unaccountable oversight the diaphragms were not drawn in the vertical sections. Each tube should have shown one diaphragm crossing it at right angles at a point about midway between its aperture and the mesial line.

This species is closely related to a common form of the Birdseye limestone in central Kentucky, which I regard as likely to prove identical with Hall's *Stictopora labyrinthica*, described from the some horizon in New York. But in the absence of any knowledge of the interior of that species, it would be highly injudicious, surely unwarranted, to assert their identity. Still, it is possible that even the Minnesota form may be only a local variety of that species. However, the probability of that supposition is so remote that I feel no hesitation in proposing the new name *varia* for the form here described.

Formation and locality.—Restricted to the middle third of the Trenton shales at Minneapolis, Minnesota. A single example from about the same horizon at Cannon Falls.

Mus. Reg. No. 5953.

Genus PACHYDICTYA, Ulrich.

Pachydictya ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 152; FOERSTE, 1887, Bull. Sci. Lab. Denison Univ., vol. ii, pt. ii, p. 162; MILLER, 1889, N. Amer. Geol. and Pal., p, 313; ULRICH, 1890, Geol. Surv. Ill., vol. viii, p. 390.

This genus, in its fullest sense, falls into three distinguishable, yet not entirely natural sections, having precisely the same relations to each other as *Rhinidictya* and *Eurydictya, Cystodictya, Dichotrypa* and *Prismopora*. These genera, being based entirely upon zoarial deviations, are evident to the unassisted eye, and the microscope is not necessary in distinguishing them. To be consequent, a similar splitting up of *Pachydictya* is suggested, but such a course would be only too liable to lead to misunderstandings, since we would be obliged, for the same reason, to follow the plan to its logical conclusion in dealing with *Ptilodictya* and *Phænopora,* in which precisely the same divisions, as well as others equally marked, obtain. It is, therefore, deemed sufficient for present needs to designate two of them with the noncommittal terms of Section *a* and Section *b*. The third, however, being a departure in a more obvious and seemingly more important direction, is entitled to better attention. For it the name TRIGONODICTYA is proposed.

The following diagnosis embraces the characters of the two sections, but those features that may be considered as especially characteristic of one or the other, are indicated by the letter *a* or *b* in parentheses following the statements.

Zoaria bifoliate, consisting of irregular wide branches, large or small, and more or less undulating, leaf-like expansions (*a*), or of narrow, subparallel-margined, and dichotomously branching stipes (*b*). Margins acute, with a non-poriferous border, obliquely striate or grano-striate. Surface with small maculæ and, about them or taking their places, clusters of zoœcia of more or less obviously larger size than the average; occasionally montiferous (*a*). In other cases (*b*) these clusters are represented by the marginal rows of apertures which are commonly of larger size, with wider interspaces, and less regularly arranged than those of the central rows. Zoœcial tubes rising rather abruptly from the mesial laminæ, the primitive cells with thin walls, longitudinally arranged, of elliptical, semicordate, or subquadrate form, in most cases partially separated from neighboring cells by small interstitial vesicles. Toward the surface their walls are thickened, often ring-like, subelliptical in cross-section, usually completely isolated, the interspaces solid excepting that they are transversed by one or more, straight or flexuous, series of minute tubuli. One or more (the number depends upon age of example) complete diaphragms in each zoœcial tube. Apertures usually elliptical, rarely subangular, the "closures" with a subcentral small opening. Interspaces grano-striate, concave and forming a peristome about the zoœcial apertures, or thrown up into longitudinal ridges. Median tubuli between the halves of the double mesial plate.

Type: *P. robusta* Ulrich.

The distinguishing characters of section *a*, which includes the type of the genus, are (1) the wide, palmate or foliar zoarium, and (2) the maculæ and clusters of large zoœcia. The section might be still further subdivided according to whether the longitudinal arrangement of the zoœcial apertures predominates, or that in diagonally intersecting series. The latter would include the species *robusta, everetti, foliata, magnipora* and *hexagonalis*, all, save the last, described by me from the lower beds of the Trenton formation; while the former would embrace the species *occidentalis* Ulrich (upper Trenton), *fenestelliformis* (Nicholson), *firma, gigantea,* and *splendens,* Ulrich (upper beds of Hudson River group), and species *obesa* and *turgida,* described by Foerste from the Clinton rocks of Ohio.

In section *b*, the zoarium is narrow, and its margins subparallel, while the longitudinal arrangement of the zoœcia is always the predominating one. It seems that maculæ, or merely an unusual width of the interspaces, must always accompany the clusters of large cells, and as the room was insufficient in these narrow zoaria for their proper development, or, it may have been that their presence would have interfered too greatly with the regular growth of the branches, they (the large cells) are instead arranged along the margins, where we may assume, the necessary conditions to have been afforded by the non-poriferous border, which is constructed essentially upon the same principle as the maculæ.*

The following species are to be arranged under Section *b: acuta* (Hall) *fimbriata, pumila,* and *triserialis,* from the Trenton; *alcyone, arguta,* and *rustica,* of Billings, from

*It is a fact worth remembering that as soon as the width of the zoarium of one of the paleozoic bifoliate Bryozoa exceeds 4 or 5 mm., a maculum or cluster of cells larger than the average is found a short distance beneath the axes of bifurcation. A still greater increase and we have a row of maculæ or monticules along the center of the surface. Several instances of this kind are illustrated on the plates accompanying this volume. (See plates VII and VIII.)

the Anticosti group; *crassa* (Hall), *bifurcata* (Van Cleve), *emaciata* (Foerste), *farctus* (Foerste), and *rudis* (Foerste), from the Clinton, and *scitula* (Hall) from the Niagara.*

In placing *Pachydictya* under the *Rhinidictyonidæ* I follow the course adopted in my 1882 work on the "American Paleozoic Bryozoa," (Jour. Cin. Soc. Nat. Hist., vol. v), and more recently in the eighth volume of the reports of the Geological Survey of Illinois, published in 1890. I have always had some doubt as to the strict propriety of the arrangement, and the chief reason for its continance in the last work is found in the fact that the genus agrees with *Rhinidictya* and all true genera of the family in having "median tubuli." Now that I am employing the classification for the third time, it seems desirable to publish at the same time some account of my objections. At first I thought some of proposing a new family for *Pachydictya* and the new genus *Trigonodictya*, but was restrained from doing so by the fear that I could not, in the present state of our knowledge, satisfactorily establish the distinctness of the new family from the *Rhinidictyonidæ*. The difficulties are encountered when we attempt to draw sharp lines between certain species of *Pachydictya* on the one side, and *Phyllodictya* and *Eurydictya* on the other. Had I made the presence or absence of diaphragms the test, I would very likely have struck the popular chord, but as I know that test to be unreliable only too often when applied to groups of high rank, I could not employ it before knowing more of its value in this particular case.

The suggested removal from the *Rhinidictyonidæ* is not caused through any depreciation in the value of the character mentioned (median tubuli), but is founded upon a better appreciation of certain features wherein *Pachydictya* and *Trigonodictya*, and in a lesser degree also *Phyllodictya*, differ from the more typical members of the family: *Rhinidictya*, *Dicranopora*, *Goniotrypa*, and *Eurydictya*. In all of the latter the primitive or prostrate portion of the zoœcial tube is of an oblong-quadrate or rhomboidal shape, the thin wall of adjacent cells being, moreover, in contact with each other on all sides. Nor are interstitial vesicles or mesopores present in any of them with the single exception of *Eurydictya multipora* (? Hall's sp.). Diaphragms, also, are very unusual, while a more or less well developed hemiseptum is common. Finally, the interspaces, as shown in tangential sections, continue uninterruptedly from zoœcial cavity to cavity, there being no sharply defined ring-like wall around the latter.

In *Pachydictya*, *Trigonodictya* and *Phyllodictya*, however, the hemisepta are never present, but complete diaphragms seem to have been developed in all examples old enough to have them. Tangential sections bring out peculiarities fully as striking and important, but their statement should be premised with the admission that some of them are but illy developed, possibly quite unrecognizable, in some of the species.

*I am convinced that several, perhaps over half, of these nine Middle and Upper Silurian species are synonyms.

Perhaps, the chief ones of the characters about to be mentioned, are those that have resulted in the presence and early development of interzoœcial spaces. These begin, generally at any rate, the same as in the *Cystodictyonidæ* and the bifoliate *Fistuliporidæ* (*Meekopora* Ulrich) at the basal (mesial) plate, causing the primitive cell of the zoœcial tubes to be in part separated from its neighbors, and to have a shape quite different from that of the *Rhinidictyonidæ*. Indeed, the resemblance to the semi-cordate cell so prevalent among the *Cystodictyonidæ*, is often very striking. (See plate IX, figs 8 and 13.) A common condition is when a small triangular interspace has been cut off from each of two diagonally opposite corners of the primitive cell. These interspaces increase in size and form shallow vesicles as growth proceeds, and as soon as the tubes have assumed an erect position, they are completely isolated by the superimposed vesicles. At the same time their walls become more or less thickened and ring-like, and, from now on to the surface, the zoœcial investment remains, almost invariably, clearly distinguishable from the interspaces proper, the sharpness of definition between them being in most cases even increased after the interspaces have been filled with the usual solid deposit. These changes in the zoœcial structure are shown in the various figures on plate IX.

In *Phyllodictya* and *Trigonodictya*, as well as in some of the small species of Section *b* of *Pachydictya*, we have no positive evidence of the development of the interstitial vesicles until after the zoœcia have left the mesial plate. In these, therefore, the basal portions of adjoining zoœcia are in contact, and in that respect the same as in *Rhinidictya*. To what extent this fact depreciates the value of the character of the partial separation mentioned in the preceding paragraph, I am not prepared to say. Perhaps it finds an explanation in this that the character, or rather the peculiar shape of zoœcium to which the early presence of interstitial vesicles is due, and which is so characteristic of Devonian and Carboniferous bifoliate Bryozoa, had not in those earlier times become fully established.

A remarkable agreement of structure is presented by certain forms of *Pachydictya* (Section *a*) with the Carboniferous fistuliporoid genus *Meekopora* (*e. g. M. clausa* Ulrich). That there exists real or ancestral affinity between them I doubt, yet, if there is none, the similarity between them is all the more curious. Nor does it seem likely that the relations with the *Cystodictyonidæ* are any closer. Still, it cannot be denied that the evidence at hand points to a relationship with those families on the one side and the *Rhinidictyonidæ* on the other.*

*A point of general interest presents itself here. As is well known, Nicholson and perhaps the majority of European paleontologists regard *Fistulipora* and its allies as belonging to the *Alcyonaria* group of corals. Now, if we will take the various species of *Pachydictya*, starting with the small forms comprised in Section *b*, which everyone concedes to be unequivocal Bryozoa, and going through to such forms of Section *a* as have the vesicular interstitial tissue well developed, we establish a chain of evidence tending very strongly to prove their view wrong. The lunarium only is lacking to make the chain complete, but, as is well known, that feature is not restricted to the *Fistuliporidæ*. Indeed, it is as well, if not better, developed in such universally conceded Bryozoa as the *Cystodictyonidæ* and *Ceramoporidæ*. But this is only one of many chains that I would very willingly publish if it were not for the time consumed in writing them up.

Section *a: Species in which the zoarium is not limited, and maculæ or clusters of large zoœcia are present.*

PACHYDICTYA FOLIATA *Ulrich.*

PLATE IX, FIGS. 1-5; PLATE X, FIGS. 5-10.

Pachydictya foliata ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 73.

Zoarium growing from an attached basal expansion into erect, thin fronds, undulating and simple, or dividing palmately or irregularly; both sides celluliferous; attaining a hight and width of 50 mm. or more, but specimens larger than 25 mm. square are rare; usual thickness about 1.2 mm., but in some old examples it is quite 3.0 mm. Margin of fronds acute or rounded, often with a distinct non-periferous border. At intervals of 3.5 or 4.0 mm. the surface presents solid, substellate spots or maculæ, that in most cases are on a level with the general plane of the surface, in others occupying the summits of low monticules, while in rare instances they may be even slightly depressed. These maculæ usually appear smooth, but when well preserved are seen to be finely grano-striate. Zoœcial apertures large, oval, arranged in regular diagonally intersecting series, in which fourteen or fifteen of the average size is the usual number in 5 mm. In the immediate vicinity of the maculæ they are larger, attaining a size of 0.4 mm. by 0.3 mm., the average size in the spaces between the maculæ being about 0.3 mm. by 0.2 mm. There is a slight difference also in the size of the apertures of the old and young specimens, they being largest in the latter. Interspaces usually of less width than the zoœcial apertures, concave and forming a distinct peristome around the aperture in the young examples; becoming flattened and even faintly convex, also minutely granulose with age. Interstitial vesicles seen at the surface in the youngest specimens only.

In vertical sections the zoœcial tubes arise rather abruptly from the mesial laminæ, the course to the surface throughout being also unusually direct. The prostrate or primitive-cells may be in contact, with a thin divisional wall; but this is not the rule since the interstitial vesicules are developed at the same time. The character of the latter is clearly preserved for a distance of about 0.5 mm. on each side of the mesial laminæ, but beyond this they are filled with solid material in which they are but illy traceable. Occasionally it is possible to detect faint dark lines passing vertically through this solid filling, indicating that communication was maintained with the horizontal median tubuli. The zoœcial tubes are bordered on each side by a double line, and crossed, according to age, by from one to five complete diaphragms. These occur approximately on the same level in all the tubes, and at intervals corresponding more or less nearly with the diameter of the tube. If my view is correct, each of these diaphragms represents the floor of distinct zoœcia which have succeeded each other by direct sequence, the formation eventually of the present "tube" being the necessary result.

In tangential sections, obtained by grinding down into one of the faces of the zoarium, we notice characters as follows: Beginning with the base of the zoœcia, *i. e.*, the mesial laminæ, we find them represented by a darkened space, (usually a meandering streak across the deepest part of the section) crossed by two sets of parallel lines, one, colorless, representing the "median tubuli" that are inclosed between the two halves of the basal plate, the other, of a dark tint, the longitudinally directed side walls of the zoœcia and intertstitial vesicles. Immediately above this space the zoœcia are slightly elongate, with the anterior end widest and rounded, and the posterior end usually truncated. Behind this is a darkened narrow space which, though really an interstitial vesicle, often appears to be a part of the zoœcium. The two together are somewhat bottle-shaped. Directly following this stage the zoœcia become shorter, broadly elliptical in shape, and separated from each other by narrow interspaces in which the elongated interstitial vesicles are more or less plainly visible. In the next stage the vesicles are more and more obscured by a seemingly structureless deposit of sclerenchyma, while the bounding wall of the zoœcia becomes more ring-like. If the section is a good one and the preservation favorable, this wall will be seen to consist of a closely arranged row of minute tubes, apparently of the same nature as the minute tubuli between the mesial laminæ. In the last stage observed (seen in a section showing the structure just beneath the surface of an old example) the interspaces are traversed by one or two intertwining lines of minute dark spots (median tubuli) and a ring of sclerenchyma, of light color and laminated structure, deposited on the inner side of the zoœcial wall. The maculæ, consisting of aggregations of interstitial vesicles, go through the same changes as the ordinary interspaces.

Good transverse sections dividing the zoarium vertically, but at right angles to the direction of growth, show, among other features, the minute tubuli between the mesial laminæ in a very satisfactory manner. A significant fact is that one of these tubuli seems always to be placed immediately beneath the walls of both the zoœcia and the intercalated vesicles. This is true, I believe, of all the *Rhinidictyonidæ*, and is strong evidence in favor of my view that the two sets of minute tubuli, horizontal and vertical, prevailing in this family of Bryozoa, communicated with each other.

A very similar form occurs near the river level at Ottawa, Canada, but as it presents several internal peculiarities, especially in the form and arrangement of the primitive portion of the zoœcia, I will pass it by with this mere mention.

The foliaceous zoarium of this species will distinguish it from all associated Bryozoa excepting *Stictoporella frondifera*. Both occur commonly on the same slabs, and a careless collector might confound them. Still, after a little study, the difference in the size and shape of their respective zoœcial apertures will become so evident that they may be distinguished at a glance.

Formation and locality—Restricted to and very characteristic of the the lower third of the Trenton shales. It is very abundant at Minneapolis and St. Paul, and has been found in greater or less abundance marking this horizon in the shales at localities near Cannon Falls, Preston, Fountain and other points in Minnesota.

Mus. Reg. No. 5948.

PACHYDICTYA OCCIDENTALIS *Ulrich.*

PLATE VIII, FIGS. 20-27; PLATE IX, FIGS. 6-10.

Pachydictya occidentalis ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 75.

Zoarium variable, sometimes consisting of narrow branches with subparallel margins, in other cases spreading rapidly into slightly undulating fronds; but the commonest mode of growth is represented in figures 20 and 24 on plate VIII. In these we have wide branches, with more or less divaricating margins, often of subpalmate form, with three or more small divisions above. Width 4 to 25 mm., greatest thickness 1 to 2 mm. Margins acute, usually with a narrow, smooth or finely striated border, best developed in the narrowest examples. The wider specimens generally with only a single row of small solid spots having the same structure as the non-poriferous border. These vary considerably in size, and are not uniform even on the same specimen. In the narrow examples they are absent except one or two just beneath each bifurcation. Zoœcial apertures elliptical, arranged in comparatively irregular series, the longitudinal predominating. Curved, transverse, and diagonally intersecting rows are also to be made out. Measuring lengthwise, thirteen or fourteen in 5 mm.; transversely, seven or eight in 2 mm. Interspaces generally rather narrow, but unequal. When an alternating arrangement of the zoœcial apertures prevails, the end spaces are decidedly the narrowest, averaging in that case only about 0.1 mm., or scarcely more than half the width of the lateral spaces. When however a transverse arrangement obtains they are nearly equal at 0.13 mm. As a rule we may say that the shorter or transverse diameter of the zoœcial apertures is about equal to the width of the interspaces. Generally the interspaces are to be described as flattened, finely grano-striate, the striæ, however, appearing to be irregular or interrupted at short intervals. In old examples they may be convex, but in no case have I detected longitudinal ridges between the rows of cells. Figure 26 represents one of a number of specimens, the growth of which for some unknown reason has not been regular and continuous over the whole surface. There seems to have been a cessation of developement in some places, causing the formation of irregular furrows, in which the old zoœcial apertures are partly closed by a sheet of dense material. Thin sections failed to reveal anything unusual, hence, we may safely assume that these specimens present merely an abnormal condition of the species.

Of internal peculiarities brought out by tangential sections the most striking are, (1) the unusual brevity of the end spaces. In many cases these are so short that the outer lines of the ring-like walls of succeeding zoœcia are often nearly in contact. Generally the length of these spaces is less or about equals half the transverse diameter of the zoœcia; (2) the continuous longitudinal lines of median pores (there is as a rule only one in each interspace between the rows of zoœcia) appears more flexuous than usual; and (3) the maculæ or solid spots, which do not interrupt the course of the lines of median tubuli. A number of isolated tubuli, otherwise seemingly of the same nature, occur between the lines mentioned.

In vertical sections the zoœcial tubes frequently have diaphragms, their course to the surface is less direct than common, and the interspaces or walls unusually thin.

The growth and maculose surface distinguishes this species from the other Minnesota forms of the genus, none of which are found, however, in the same beds with *P. occidentalis.* Though perhaps still to be regarded as intermediate in some respects between *P. acuta* Hall, sp., and *P. fenestelliformis* Nicholson, sp., further investigation proves the relationship to those species to be more remote than I thought at first. It seems also to have preceded both in time. Compared with the first it is found to differ in its mode of growth, the zoarium being wider, in the character of the interspaces, and in the maculæ which are wanting in that species. The second has larger zoœcia, and both present well marked internal differences.

Formation and locality.—Rather abundant in the upper third of the Trenton shales at St. Paul, Minnesota. A few specimens also from the same horizon in Goodhue county.

Mus. Reg. Nos. 5949, 7646.

Section *b: Species in which the width of the zoarium is limited, and the margins subparallel.*

PACHYDICTYA FIMBRIATA *Ulrich.*

PLATE VIII, FIGS. 28-34; PLATE IX, FIGS. 13 and 14.

Pachydictya fimbriata ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 75.

Zoarium rather small, ramose, the branches with subparallel margins, from 2 to 5 mm. wide, averaging a little over 3 mm., thin, the thickness rarely exceeding 0.5 mm.; bifurcations dichotomous, occuring at variable though generally at long intervals; angle of bifurcation unusually wide. Non-poriferous margin very wide, extremely thin and sharp, and wavy or ruffled; its surface is obliquely striated, the striæ really rows of minute hollow papillæ, which communicate with the horizontal median tubuli between the mesial laminæ. Zoœcia in from seven to twelve ranges, the usual number ten or eleven; their apertures elliptical, usually a little wider than the transverse interspaces, and longer than the end spaces. In the five, six, or seven central rows the apertures are arranged in regular alternating or subalternating longitudinal series, in which thirteen or fourteen occur in 5 mm.; measuring transversely six rows take up a space of 1.5 mm. wide. The one to three marginal rows are not so regular in their arrangement, they being, besides, appreciably larger and separated by wider interspaces, while their long diameter is, usually at least, directed somewhat obliquely outward.

On plate IX, fig. 13 represents part of a tangential section, showing, at the top, the primitive or prostrate portion of the zoœcia, and mesial laminæ with horizontal tubuli; along the right side, the wide non-celluliferous border, which in thin sections is irregularly outlined and incomplete, because of its "ruffled" character; and in the lower left-hand fourth, the zoœcia and interspaces as they appear just beneath the surface. In the last portion of the figure the chief feature to be pointed out is the unusual clearness and thickness of the ring-like zoœcial investment. In common with perhaps every species of this section of the genus, and many of section *a*, the longitudinal arrangement of the zoœcia between distinct lines, either straight or flexuous, and proving on closer inspection to be series of minute pores, prevails in the central rows through all stages, saving, perhaps, the last in very old examples.

Good examples of this species cannot be confounded with any other known to me, since the great width and wavy or ruffled character of the non-poriferous margin gives them a very striking and highly characteristic aspect. In most other respects the species resembles *P. acuta* Hall, sp., and its western varieties rather closely. It may be compared also with *P. elegans* and its *described* variety. In that species and variety the non-poriferous margin is also rather wide, but it is not wavy and the inter-apertural spaces are wider, especially those between the ends of the zoœcial apertures, while the whole surface of the zoarium strikes one as more highly ornamental. Considerable differences are likewise to be noted in tangential sections as may be seen in comparing figures 8 and 13 on plate IX.

Formation and locality.—Rather common in the lower half of the Trenton shales at Minneapolis and St. Paul, Minnesota. It occurs also in the "Pierce" limestone of Tennessee.

Mus. Reg. Nos. 5950, 5951.

Pachydictya elegans. *n. sp.*

PLATE VIII, FIGS. 18 and 19. PLATE IX, FIGS. 8 and 9.

The nearly complete type specimen began its growth on the extremity of some undetermined ramose bryozoan. The basal expansion is small, and its surface largely covered with granulose striæ. At its edges, where it grew downward on the foreign body, a few apparently normal zoœcia were developed. From the exceedingly short, neck-like constriction above the base, the erect portion of the zoarium divides at once into three branches, and two of these continue to divide dichotomously with extraordinary frequency, the average distance between bifurcations being only 5 or 6 mm. This frequent division caused the zoarium to spread with unusual rapidity; some of the inner branches must have overlapped if continued. We may assume, however, that with age, beyond that shown in this example, the outer or subsequent divisions became less frequent, or at any rate, dependent upon the space available for lateral development. Branches 2.5 mm. to 5.0 mm. wide, thin, edges sharp, non-poriferous, border wide, obliquely grano-striate. In the thickest specimens the celluliferous portion of the branch rises abruptly from the wide non-poriferous borders, the growth of the latter having failed to keep pace with that of the zoœcia. Under a good hand lens the surface presents a highly ornamental appearance, the arrangement of the zoœcia and sculpture of the interspaces being very regular. Apertures elliptical, separated from each other by spaces as wide as their shorter or transverse diameter. In the central rows the arrangement is alternate, with thirteen or fourteen in 5 mm., measuring lengthwise, and seven of the central rows in 2 mm., transversely. Those in the marginal rows slightly oblique, a little larger than the average and separated by correspondingly wider interspaces, so that a smaller number occurs here in a given space than in the central series. Surrounding each aperture a sharply defined rim or peristome, and rising from the center of the depressed spaces between the longitudinal rows, a faintly flexuous, thread-like line. On the best preserved portions of the surface, both the longitudinal lines and the peristomes are seen to carry a row of minute papillæ. Over the central part of the surface the depressed end spaces are narrow and usually empty, but toward the margins, where they are wider, they are occupied by a gradually increasing uumber of papillæ, at first isolated, then forming short outwardly tending rows.

Provisionally I propose to place here a number of specimens agreeing in all respects with the type of the species, save in this, that they bifurcate at less frequent intervals. The interspaces in many are a trifle thicker, but as these specimens are heavier and evidently older, that is to be expected.

The internal characters, which in most respects remind us greatly of *P. occidentalis*, surely more of that species than of *P. acuta*, were obtained from thin sections of one of the last mentioned specimens.

Compared with other species *P. occidentalis* offers many points of agreement, but, so far as known, is distinguished readily enough by its maculæ, and the less regular arrangement of its zoœcia and inter-apertural markings. *P. fimbriata* is also closely related, but the peculiar wavy character of its borders serves well in separating them. In *P. acuta* and varieties the spaces separating the rows of apertures are more ridge-like, and the end spaces longer. The branches also are, except in rare instances, narrower.*

Formation and locality.—Not uncommon in the Galena shales at St. Paul, Minnesota, where it is associated with an abundance of *Zygospira recurvirostris* (Hall) and segments of *Arthroclema*. *Arthropora reversa* is found on the same slabs of rock. Also at Decorah, Iowa.

Mus. Reg. No. 7596.

PACHYDICTYA ACUTA *Hall*, and varieties.

PLATE VIII, FIGS. 11-17; PLATE IX, FIG. 7.

Stictopora (?) *acuta* HALL, 1847. Pal. N. Y., vol. i, p. 74, pl. xxvi, figs. 3a, b.
Stictopora or *Ptilodictya acuta* (part.) of many authors.
Stictopora acuta ULRICH, 1882. Jour. Cin. Soc. Nat. Hist., vol. v, p. 168, pl. viii, figs. 1, 1a, 1b.
Pachydictya acuta ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat Hist. Sur. Minn., pp. 75 and 76. (Merely mentioned as a species of *Pachydictya*.)

This so frequently yet so often incorrectly quoted species, has given me no little trouble, first, because of the difficulty of determining exactly what species Hall originally intended, and second, because of its variability. The species might be subdivided, but I doubt the advisability of doing so, since most of the varieties are exceedingly difficult to recognize. The species, with all its varieties, is also restricted to the Trenton limestone, or rocks equivalent to that horizon. Hence, we have not the usual though good excuse for proposing varietal distinctions. The species is to be regarded as one of the most characteristic and widely distributed fossils of the Trenton proper, being also abundant at many localities in New York, Vermont, Canada, Kentucky, Tennessee, Illinois, Wisconsin, Minnesota, and Manitoba. It has been reported to occur in the Birdseye and Black River horizons, but that is most likely an error, species of *Rhinidictya*, which abound in those rocks, having but too often been confounded with *P. acuta*.

Figure 11 of Plate VIII, represents one of seven fragments from the original locality, Trenton Falls, New York, which I owe to the kindness of Mr. C. D. Walcott. Its surface magnified nine diameters is shown in fig. 12 of the same plate. In this

* Though now obliged to regard *P. elegans* as specifically distinct, I expect, with material soon to be gathered, to be able to show that it is merely a later development of *P. occidentalis*. Perhaps also that it is really an intermediate stage between that species and *P. acuta*.

specimen, which may be assumed to represent the typical form of the species, the zoœcial apertures are elliptical, rather small in the central rows where, however, they are separated by comparatively long intervals, with twelve in 5 mm. In the marginal row the zoœcial apertures are rather oblique and conspicuously larger, and here only eight or nine are to be counted in the same space. The non-poriferous margins are wide, and where the preservation is good, have the usual oblique granulose striation. The interspaces form faint longitudinal ridges, while a delicate rim is to be detected here and there around the sunken apertures. In some of the other fragments the surface is preserved better, or, as is more likely, it presents a less aged condition, and in these the peristome is more distinct, as is also a thin raised line passing between the central longitudinal rows of apertures. The general effect, therefore, is much as in fig. 32 of the same plate, only the zoœcial apertures are narrower and farther apart, and the marginal ones larger.

The New York, Canadian and Vermont specimens, or as we may call them, the eastern form of the species, is fairly constant in every respect. The zoarium divides dichotomously at rather long intervals, the length of these varying between the extremes of 10 and 20 mm., while the width of the branches between the bifurcations, where the margins are parallel, is rarely more than 3.0 mm., and so far as noticed, never less than 2.5 mm. The number of rows of zoœcia is generally seven or eight.

In the western form, however, we find a greater or less degree of instability in nearly every character. This is to be remarked especially of the Minnesota specimens. The branches, as a rule, are considerably wider, the average varying between 3.5 mm. and 5.5 mm. Still, it is not rare to find specimens, particularly among those from the lower beds of the Galena limestone, that are narrower, with the average at about 2.0 mm. Figure 16 represents an example that may be compared with the eastern form in the matter of branching, but in a great majority of the western specimens the divisions are much closer, the average distance between them being about 10 mm., and in many less. Another point to be noted is the tendency to irregularity in the growth of the zoarium of the western form, abortive branches, trifurcations and unparallel margins being common, while its appearance in general is less rigid than is prevailingly the case in the eastern form. The non-poriferous margin may be wide or narrow, but it is rare, if it ever occurs, to find an amount of difference in the size of the zoœcial apertures in the marginal and central rows equalling that prevailing in the eastern form. As a rule, the difference may be stated to be greatest in the smaller examples and least in the wide ones. The number of zoœcia rows varies from six to eighteen, with eleven, twelve and thirteen the number most frequently met with. In the central rows twelve, thirteen or fourteen apertures, the two last numbers more common than the first, occur in 5 mm. In well preserved examples a thin peristome is clearly distinguishable, and, running lengthwise between the rows of apertures, a thin ridge raised considerably or only slightly above the level of the peristomes. The interspaces are always as wide as the zoœcial apertures, and in many specimens nearly twice as wide. One specimen preserves a few "closures" or zoœcial covers. These are faintly convex, with a small rounded opening in the anterior half.

Of internal characters, I shall mention, (1) the absence of interstitial vesicles between the primitive or prostrate cells of the zoœcia; (2) the contact of those portions of the zoœcia with each other on all sides, resulting from the absence of the vesicles; (3) the peculiar convex shape of the anterior or transverse partitions of the primitive cells; (4) the density and early beginning of the solid interstitial filling, and consequent indistinctness of the vesicles. Diaphragms are usually present, one or two in each tube.

Compared with other species, *P. elegans* is found to differ, externally, in its usually wider and more rapidly branching zoarium, and flatter interspaces; internally in the shape of the primitive cell and the earlier development of the intersititial vesicles. *P. occidentalis* is sufficiently distinguished by its mode of growth and its maculose surface, and *P. fimbriata* by its peculiar ruffled non-poriferous margin.

Formation and locality.—This species is one of the commonest fossils of the Galena shales, having been found at perhaps every one of the numerous localities in the state where that horizon is exposed. Also at Decorah, Iowa. It occurs also in the lower layers of the overlying limestones, at Fountain, and several specimens have been collected from the *Phylloporina corticosa* horizon. Its wide geographical distribution outside of the state has been mentioned already.

Mus. Reg. Nos. 7607, 7609, 7616, 7619, 7623, 7632, 7639, 7643, 8027.

PACHYDICTYA PUMILA *Ulrich.*

PLATE X, FIGS. 1-4.

Pachydictya pumila ULRICH. 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 186, fig. 11.
Rhinidictya humilis ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 185, fig. 10.

Zoarium bifoliate, small, usually less than 1 cm. in height, growing rather irregularly. Branches from 1.0 to 1.5 mm., wide, generally bifurcating at intervals of from 2 to 4 mm., but some fragments observed are undivided for a distance of 6 or 8 mm. Zoœcia in from three to six ranges, with four or five the average number shortly after bifurcations. The arrangement of their oval apertures is inclined to be rather irregular, though more or less longitudinal rows prevail in most cases. Over the basal parts of the zoarium this irregularity is apparent in a higher degree than in the distal portions. In the latter five to seven occur in 2 mm. longitudinally. The size of the apertures and the general appearance of the surface varies with age and other conditions. Nearly complete examples may show all the phases.

In the very young specimens, or at the distal extremities of the branches of the more mature ones, the zoœcial apertures are comparatively large, the lateral interspaces correspondingly narrow, and the end spaces with one or two depressions. In this stage the interspace granulations are very faint, but in the succeeding stages they are much better defined, the apertures often smaller, with the width of the interspaces increasing with greater rapidity, the increase in the circumference of the branches being divided between the lateral interspaces. In most of these specimens the interspaces are now flat or faintly concave, with a more or less distinctly recognizable though thin peristome about the apertures. In others a row of the interstitial papillæ occupies a faint longitudinal ridge, that may be elevated to slightly above the level of the peristomes. In more rare instances the peristomes appear to be wanting over parts of the surface, and the whole interspace convex and irregularly granulose, and seeming to slope down into the apertures. These specimens have quite a different aspect from the ordinary form of the species, indeed, so much so, that I mistook them for a species of *Rhinidictya.* Non-poriferous margin never wide, often so narrow as to be practically wanting. Its surface is papillose. Not infrequently large patches of the surface, where the zoœcial apertures have been closed by a thin deposit of calcareous material, are covered with such papillæ.

Internal characters vary much as in *P. acuta,* excepting that they are all a little smaller, and the transverse walls between the prostrate cells of the zoœcial tubes straighter.

When the preliminary description of this species was written I had unfortunately mislaid the two specimens regarded as the types of the form named *Rhinidictya humilis,* and which I believed to have been derived from the lowest shales at Minneapolis. In preparing the Minnesota material for my final studies they were found and the label with them proves that they were really collected at the same time and from the same beds as the original specimens of *P. pumila.* Later washings of the shales from this locality have added greatly to the number of specimens. With this more complete representation of the species I have become satisfied that the supposed *Rhinidictya* exhibits merely another phase of surface marking of *P. pumila,* deserving not even subordinate distinction. Among the lot, however, there is a form of which I have over twenty specimens, that might be distinguished as var. *sublata.* The zoarium does not appear to have been much larger than in the typical form, but its branches are wider, and though there are generally two or three rows of zoœcia more than in the largest of the type form, the greater width of the branches is chiefly due to a wide non-poriferous margin.

The small, dwarfish appearance of the zoarium of this species will distinguish it from all others of the genus known to me. In other respects the species resembles *P. acuta* Hall, which occurs associated with it, but because of the much smaller size of *P. pumila* confusion between them is rendered highly improbable. Another associated species, *Rhinidictya minima*, is more likely to be confused with it, but after a little comparative study, the student will find himself able to distinguish them almost at a glance. The rather rigid and subcylindrical character of the stems of the next described *P. triserialis* are sufficiently distinctive of that species, and render further comparisons unnecessary.

Formation and locality.—Base of the Galena shales, near Cannon Falls, Minnesota, where it is associated with species of *Nematopora*, *Arthroclema armatum*, *Helopora mucronata*, and other small Bryozoa, all of them characteristic of the horizon. A single example apparently referable to this species, was found at the horizon of *Phylloporina corticosa*, and another occurs on a slab of Trenton limestone, from Trenton Falls, New York.

Mus. Reg. No. 8107.

Pachydictya triserialis *Ulrich.*

PLATE X, FIGS. 11-14.

Pachydictya triserialis Ulrich, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 187, fig. 12.

Zoarium consisting of very slender, parallel-margined, subcylindrical or compressed branches, 0.6 to 0.8 mm. wide, and 0.3 to 0.55 mm. thick; branches bifurcating at intervals of from 5 to 10 or more mm., oval or obtusely hexagonal in cross-section, the margins never, or at any rate but rarely, acute, in most cases to be described as narrowly rounded. Each face with three rows of longitudinally arranged zoœcial apertures, occasionally with a fourth row, but only for a short distance. These rows are often not exactly parallel with the margins of the branches, a faint tendency to arrangement in long spirals being perceptible in those cases. Zoœcial apertures elliptical, nearly twice as long as wide, largest in young or worn examples, separated by intervals equal to their long diameter, with from 11 to 13 in 5 mm.; occasionally enclosed by a delicate rim or peristome, but oftener with sloping edges. Between the rows an obtuse ridge. Entire surface, especially of the older portions, minutely papillose. Non-poriferous margins narrow, readily overlooked, generally wider on one side than on the other.

Internal characters similar to those of *P. acuta* Hall, and *P. pumila*. In such a small species the interstitial vesicles are necessarily reduced to a minimum, and in this one the solid filling of the interspaces is so dense that their original presence is not easy of demonstration.

The subhexagonal narrow branches of this species present considerable resemblance to species of *Nematopora* like *N. lineata* (*Helopora* 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 zoœcia 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.

Formation and locality.—As yet known only from the Trenton limestone at Montreal, Canada, but it is not at all unlikely that the species is to be found in the Minnesota equivalent of that horizon.

Genus TRIGONODICTYA, n. gen.

Zoaria with triangular branches, constructed upon the plan of *Prismopora*, but with zoœcia and all minute details of structure precisely as in *Pachydictya.*

Type: *Pachydictya conciliatrix* Ulrich.

Another species occurs in the Clinton rocks near Eaton, Ohio, which, because it is the only bryozoan with triangular branches known to me from Upper Silurian strata, and may therefore be distinguished from associated forms with ease, I propose to name *Trigonodictya eatonensis,* n. sp. It is rather more slender than the Trenton species, and its branches divide at less frequent intervals. The three surfaces are also flat instead of concave, while in thin sections the interspaces between the comparatively large oval zoœcia are thinner, and the lines of erect median tubuli much less distinct and not so numerous.

TRIGONODICTYA CONCILIATRIX *Ulrich.*

PLATE IX, FIGS. 11 and 12; PLATE X, FIGS. 15-20.

Pachydictya conciliatrix ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 76.

Zoarium of irregular growth, dividing at frequent intervals, consisting of equal-sided triangular branches, with the three faces concave, each averaging about 3 mm. wide; or of more or less rapidly spreading, small, flabellate fronds, with from one to five salient, divaricating ridges on only one or both sides. All intermediate conditions between these two extremes occur. Each of the surface ridges has a non-poriferous, sharp summit, and, beginning as a mere line, it rises gradually until it is sufficiently high to permit of the formation of a new triangular branch, when it forms one of its edges. Zoœcial apertures elliptical, slightly oblique, smallest and arranged longitudinally over the central half of each face; here with 12 or 13 in 5 mm., a faintly elevated line between the rows, and the width of the longitudinal and lateral interspaces generally about equal to the respective diameters of the apertures. Toward the non-poriferous edges the apertures are directed obliquely upward and outward, and increase in size gradually till those in the outermost row are quite twice as large as those in the central rows. When the surface is weathered the zoœcial apertures are larger than normal, and their longitudinal arrangement less obvious, the interspaces rounded, and without the series of minute papillæ that are always present when the surface is well preserved.

In considering the internal characters it should be borne in mind that but few tangential sections are at all likely to be made that will show the structure as fully and clearly as in fig. 12 (plate IX). The section from which this drawing was made is an exceptionally good one, having been prepared from a fragment in an unusually good state of preservation; so that it shows the structure just beneath the surface in a very satisfactory manner. At the sides of the figure, the left-hand one especially, the horizontal median tubuli are represented, and a short distance from the edge we see how the vertical series of these tubuli arise out of the horizontal set.* At a deeper level than any shown in the figure, the zoœcia are larger and rounder, and the interspaces proportionally narrower, and, with the exception of a dark line running longitudinally between the rows of zoœcia, generally appear structureless. A little deeper and a few irregular lines, representing the walls of interstitial vesicles, may be noted in the interspaces.

Transverse sections show that in the regularly developed triangular branches each is divisible into three subequal triangular parts, bounded by a mesial line from which the zoœcial tubes of each part proceed to their respective external faces. New angles and faces are produced by raising one of the plate-like longitudinal walls until it has assumed the characters of a mesial plate.

The zoarial features of this species are so strikingly different from all known Lower Silurian Bryozoa that comparisons are unnecessary. For remarks on the Clinton group species of the genus, see under the generic description.

Formation and locality.—Apparently restricted to the upper third (Phylloporina horizon) of the Trenton shales, near Cannon Falls, Minnesota.

Mus. Reg. No. 5952.

Family PTILODICTYONIDÆ, Zittel.

For a description and remarks on this important family, the reader is referred to my recent work in the eighth volume of the reports of the geological survey of Illinois, pp. 348 and 390.

Five genera of this family are represented in the Trenton shales of Minnesota, and, so far as known, the species here described of each are the earliest existences

*This is not only an interesting fact, but, as are all that relate to the intercommunication of the zooids, also one of great importance morphologically.

of not only their respective genera but of their entire family. In every case the generic features are fairly developed, indicating that the primal stock is yet to be discovered in previously deposited rocks. Still, in the three most typical members of the family, *Ptilodictya*, *Escharopora* and *Phænopora*, the resemblance between the primitive species of each is more evident than in the species that occur in deposits of later date.

Indeed, in these early Bryozoa we often meet with species that combine, sometimes to a very perplexing degree, characters which in latter times have attained the stability and importance of generic structures. *Escharopora confluens* and *E.* (?) *limitaris* are cases in point, since they have much to remind us of *Phænopora;* not of the fully differentiated Upper Silurian forms of that genus, but of the Lower Silurian species which obviously had not yet attained the full expression of the generic characters. From the facts already available we are, I believe, justified in assuming either that *Ptænopora* and *Escharopora* are contemporaneous offshoots from a more primitive stock, with characters in general like those of *E. confluens;* or that *Escharopora* was the stock from which first *Phænopora* and then *Ptilodictya* were evolved. In the development of the former, the connecting channel between the apertures was cut off by the formation of a rim at their ends. The mere depression to which the channel was thereby reduced, was next deepened, chiefly at the ends, thus giving rise to the two mesopores between the ends of the zoœcial apertures. These are already well developed in *Phænopora incipiens*, but like all incipient characters are as yet a little unstable. The later development of the genus consisted principally in the greater separation of the longitudinal walls between which the primitive cells were arranged. This caused a shortening of the longitudinal inter-apertural spaces, with the result that the "two mesopores" were obliged to change their arrangement from the longitudinal to the transverse.

The prostrate portion of the zoœcial tubes of early *Phænopora* is very narrow and elongate, just as in the contemporaneous species of *Escharopora*, and the tendency to shorten and widen the primitive cell (already mentioned) exhibited in Middle and Upper Silurian times, seems to have obtained through all the most typical members of the family.

The systematic position of *Stictoporella* is undoubtedly near that of *Intrapora*, Hall, *Tæniodictya*, *Stictotrypa*, and *Ptilotrypa*, Ulrich. These five genera, it seems to me now, should be classed together, but whether they ought to be regarded as con stituting a distinct family by themselves, or had best be retained as members of the *Ptilodictyonidæ*, the position assigned to them in my recent work on the Illinois Bryozoa, is a question that I am not yet prepared to solve. The *Ptilodictyonidæ* would surely be a more compact and obviously characterized group if they were removed, for in that case we would have one easily recognized though not peculiar character running through the family that is not represented in *Stictoporella* and allied genera.* A basal articulation, namely, pertains to *Ptilodictya*, *Escharopora*, *Phœnopora*, *Clathropora*, *Graptodictya*, and *Arthropora*, while in *Stictoporella* and genera of that type, the zoarium is continuous throughout, and attached below in the ordinary manner, *i. e.* by a simple basal expansion forming one piece with the erect frond.

If removed from the *Ptilodictyonidœ* it would be necessary to establish a new family for their reception, since they cannot, because of the absence of median tubuli between their mesial laminæ, be placed with the *Rhinidictyonidœ*, the only remaining family of paleozoic Bryozoa with which they have any affinity. It was because they agree in this and most other respects with *Escharopora*, that I arranged them with the more typical *Ptilodictyonidœ*. The new family would hold an intermediate position between the *Rhinidictyonidœ* and *Ptilodictyonidœ*, differing from the former in its zoœcial characters, and from the latter in its continuous zoarium, presumably a zoarial modification.†

Genus PTILODICTYA, Lonsdale.

Flustra (part.), GOLDFUSS, 1826. Petref. Germ.
Ptilodictya, LONSDALE, 1839, Murch. Sil. Syst., p. 676.
Ptilodictya (part.), NICHOLSON, 1874. Geol. Mag., n. s., vol. i, p. 123, and Pal. Ont., p. 97; VINE, 1881 Second Brit. Assoc. Rep. Foss. Poly., Quar. Jour. Geol. Soc. Feb. 1882, and 1884, Fourth Brit. Assoc. Rep. Foss. Pol., p. 37; ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 151, and 1890, Geol. Surv. Ill., vol. viii, p. 390; HALL, 1887, Pal. N. Y., vol. vi, p. 19.
Escharopora, HALL, 1874 and 1879. Twenty-sixth and Thirty-second Rep. N. Y. State Mus. Nat. Hist. (Not 1847, Pal. N. Y., vol. i.)
Heterdictya, NICHOLSON, 1875. Geol. Mag., and Pal. Ont., (ii) p. 79.

In my preliminary report on the Bryozoa of Minnesota (Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p, 64; 1886) I mention the two sections into which *Ptilodictya*, as understood by me in 1882 (*loc. cit.*), may be divided. Since then I have given the subject further study, with the result that I now believe they may be distinguished in a generic sense.

*An articulated zoarium is of rather common occurrence among both the living and extinct Bryozoa. Of Paleozoic types the *Arthrostylidœ* and true *Ptilodictyonidœ* are the best representatives of this method of growth. It is also characteristic of *Acrogenia*, Hall, and *Dicranopora*, Ulrich.

†In drawing this distinction the systematist is once more called upon to decide between zoarial and zoœcial variations as furnishing the best and most reliable tests of relationship. The more I study these questions of relationship, the less practical seems the adoption of strict rules for our guidance in the delimitation of the classificatory sections whereby we attempt to express our ideas of natural modifications. What may appear as, and probably is, sufficient ground for the erection of a genus or family in one case, does not necessarily suffice in another. There are so many points to be taken into account before anything even approximately expressing nature's handiwork can result. Among them, environment, association, and relative position in the geological scale, are of great importance. The last, if judiciously used, is always an excellent clue to relationship, and one that has been but too rarely taken into consideration by students of recent zoology. Volumes are to be written upon these intricate questions, but I have said enough probably to show that a successful classification cannot be worked out in a day, nor is any yet drawn up that will not suffer greater or less modification in time. The stability of a classification depends not a little upon the collector, since it is his discoveries that build it up or tear it down.

The divisions are perfectly natural, and each based upon readily detected peculiarities. In the first, including *P. lanceolata* Goldf., sp., and therefore *Ptilodictya* in the strict sense about to be proposed, we have a character that is wanting in the second: Namely, a variable number of regular longitudinal rows of zoœcia running through the center of the fronds from the pointed articulating base upward. In the earliest species having this peculiarity, these longitudinal central rows do not always extend through the frond to its upper extremity, but they are sometimes found to pass into the diagonal arrangement prevailing over the lateral portions of the surface. In *P. magnifica* Miller and Dyer, for instance, the longitudinal rows obtain only in the middle of the lower half of the full grown zoaria, the diagonal arrangement being present on all other parts of the surface.

These central zoœcia are oblong-quadrate in shape, narrower than the lateral ones, and always the first to be developed. In the youngest examples of all the species they alone occur, and it is only in later stages that the differently arranged and wider lateral zoœcia are developed. It is possible that this condition, which, as said, is an immature or youthful one in most of the species, may have persisted in some, and that in these no lateral zoœcia were produced. *P. gladiola* Billings, and *P. flagellum* Nicholson, may be said to support this view, only longitudinal zoœcia being as yet known of them. Still, as the evidence is merely negative, and in the light of facts brought out in a study of complete suites of *P. variabilis* of the Hudson River group, I am obliged to regard the matter as doubtful.

Used in this restricted sense *Ptilodictya* admits of subdivision into two groups, both obvious enough, but, as they now appear to me, not quite natural. In the first, with *P. lanceolata* as the type, we have either nothing but longitudinal rows of zoœcia, or these are flanked on each side by spaces of greater or less width over which the apertures are arranged in an oblique manner, giving the fronds the fancied resemblance to a feather that suggested the generic name. The lateral rows proceed to the edges of the zoarium without interruption from either groups of large cells, monticules, or maculæ.

In the second subdivision, and of this *P. magnifica* M. & D. may be considered as typical, the zoœcial apertures on the lateral extensions of the zoarium are arranged in diagonally intersecting series, with clusters of large cells, monticules, or maculæ, at regular intervals. The pinnate arrangement of parts prevailing in the lanceolate subdivision is therefore scarcely recognizable in this, but the presence of monticules is an even more striking peculiarity.

In the second division, for which I propose to adopt Hall's name *Escharopora*,* the

* I have some slight doubts respecting the specific characters of *E. recta*, Hall, the original type of the genus, but none whatever so far as its generic characters are concerned.

diagonal arrangement of the zoœcia prevails throughout; so that instead of narrow oblong-quadrate zoœcial apertures along the center of the fronds, we have there, the same as on all other parts of the surface, rounded apertures situated in rhomboidal or hexagonal spaces.

A subdivision of *Escharopora* is likewise possible, but in this case we make out three instead of two. In the first we have simple narrow zoaria, with the diagonal lines of zoœcia extending without interruption, completely across the celluliferous faces. *E. recta* and *Ptilodictya falciformis* Nicholson, are good examples. In the second the zoaria are also simple, but wider, occasionally very large (*e. g. Ptilodictya pavonia* d'Orb.) and at regular intervals their surfaces exhibit clusters of large cells. The latter are commonly elevated into rounded or conical monticules.

These two subdivisions though obvious enough and in the main indicative of natural relations, are nevertheless not entirely so, since they separate species like *P. falciformis* Nicholson, and *P. maculata*, that most certainly are closely allied, and in practice sometimes difficult to distinguish even specifically. Again, we know forms, *Escharopora* (*Ptilodictya*) *subrecta* for instance, in which old examples, or may be they are entitled to the distinction of a variety, have one, two, or even three rows of monticules. On the other hand, I am fully convinced that in the young zoaria of the normally montiferous species, the monticules were, to say the least, a very inconspicuous feature compared to what they are on the fully matured zoaria (See footnote, ante p. 146.)

The third subdivision includes the branching forms. So far as known, it is a natural grouping, and distinguished from the preceding by the branching of the zoaria, and parallel margins of the branches after the first or basal division. When the branches are wide, clusters of large cells and monticules are developed, but when they are narrow, the monticules are absent, and the large cells distributed along the non-poriferous edges. A subdivision of the branching forms is possible therefore precisely as in the simple species.

In accordance with the above I offer the following amended definition of *Ptilodictya* and *Escharopora*, and classification of species.

Genus PTILODICTYA, Lonsdale, 1839.

Zoaria bifoliate, simple, umbranched, lanceolate or falciform, terminating below in a solid, striated, pointed base, which originally fitted loosely in the centrally situated cupshaped depression or socket of a small basal expansion. The latter grew fast to foreign bodies, is radially striated, and has small cell openings in the furrows between the striæ. In very young examples, and in certain small species in which this condition seems to be permanent, the entire zoarium consists of longitudinally arranged, narrow, oblong-quadrate zoœcia. As growth proceeded new zoœcia, both wider and differently arranged, were added on each side. These lateral zoœcia may be arranged in oblique or transverse rows, so as to produce the "pinnate" or "plumose" arrangement prevailing in the typical species, or they may form diagonally intersecting rows, with groups of large cells or subsolid spots raised at regular intervals into monticules. Zoœcial apertures subquadrate, rhomboidal, or rounded, the shape depending largely on their arrangement.

Both hemisepta usually well developed. Primitive cell, with thin walls, subelongate, quadrangular, hexagonal, or lozenge-shaped, in contact at all sides. In the vestibular or outer region, the walls are more or less thickened, solid, and with a double row of exceedingly minute dots; the latter rarely preserved and seen only in tangential sections. No median tubuli.

Type: *P. lanceolata* Goldfuss, sp.

CLASSIFICATION OF SPECIES.*

Section *a;* without monticules.

P. lanceolata Goldf., Upper Silurian, Europe.
P. expansa Hall (not *Phœnopora expansa* Hall and Whitefield), Clinton group, Ohio.
P. gigantia (*Heterodictya gigantia* Nicholson), Corniferous limestone, Canada.
P. canadensis Billings, Hudson River group, Canada.
P. flagellum Nicholson, Cincinnati group, Ohio.
P. gladiola Billings, Hudson River and Anticosti groups, Anticosti.
P.(?) sulcata Billings, Anticosti group, Anticosti.
P.(?) angusta Hall, Niagara group, Indiana.

Section *b;* with monticules.

P. magnifica Miller and Dyer, Cincinnati group, Ohio, Illinois and Indiana.
P. plumaria James (as figured by Ulrich) Cincinnati group, Ohio, Indiana and Illinois.
P. variabilis Ulrich, Cincinnati group, Ohio and Indiana.
P. whiteavesi Ulrich, Hudson River group, Manitoba.
P. nebulosa Hall, Lower Helderberg group, New York.

No species of *Ptilodictya*, as here restricted and defined, have yet been brought to my notice from Minnesota deposits, but it is not improbable that *P. magnifica* M. and D., occurs in the upper beds of the Hudson River group in the southern part of the state, that species having been noticed as far to the northwest as Wilmington and Savannah in Illinois.

* A number of foreign species have been described as *Ptilodictya*, but in the absence of specimens I do not consider myself warranted to attempt their classification.

Genus ESCHAROPORA, Hall.

Escharopora, HALL, 1847. Pal. N. Y., vol. i, p. 72.
Ptilodictya (part.), ULRICH and many other authors.

Zoaria bifoliate, simple or branching, pointed below, and articulating into a spreading base as in *Ptilodictya*. Zoœcia arranged in regular diagonally intersecting series throughout. In the small species these rows extend in a continuous line across the fronds, but in the larger forms their course is interrupted at more or less regular intervals by the development of raised clusters of large cells. Apertures rounded, elliptical or subcircular, set into sloping areas; the latter generally of rhomboidal or hexagonal shape and sharply defined, in other cases longitudinally confluent, and connected by a narrow channel.

Internal structure essentially as in *Ptilodictya*, the differences chiefly due to the different zoœcial arrangements.

Type: *E. recta* Hall, Pal. N. Y., vol. i, p. 72; 1847.

Better known examples are *Ptilodictya falciformis* Nicholson, Pal. Ohio, vol. ii, p. 259, 1875, and *P. pavonia* d'Orbigny, Prodr. de Pal., vol. i, p. 22, 1850.

CLASSIFICATION OF SPECIES.

Section *a*; zoaria simple, without monticules.

E. acuminata (James), Galena limestone, Iowa; Utica horizon of the Cincinnati group, Ohio and Kentucky.
E. angularis, n. sp., lower Trenton, Minnesota.
E. falciformis (Nicholson), Cincinnati group, Ohio, Indiana, Kentucky.
E. recta Hall, Trenton limestone, New York, Canada, ?Galena shales, Minnesota.
E. subrecta (Ulrich) lower Trenton shales, Minnesota.

Section *b*; zoaria simple, with monticules.

E. hilli (James, as figured by Ulrich), Cincinnati group, Kentucky.
E. libana (Safford), Birdseye limestone, Kentucky, Tennessee.
E. maculata (Ulrich), Cincinnati group, Ohio, Kentucky.
E. pavonia (d'Orbigny), Cincinnati group, Ohio, Indiana, Kentucky.
E. n. sp., Birdseye limestone, Tennessee.
E. n. sp. (near *pavonia*), top of Trenton, Nashville, Tennessee.
E. n. sp., Cincinnati group, Kentucky.

Section *c*; zoaria branching.

E. briareus (Ulrich), Birdseye limestone, Tennessee.
E. confluens, n. sp., lower Trenton shales, Minnesota, Tennessee.
E. ramosa (Ulrich), Birdseye limestone, Tennessee, Kentucky.
E. n. sp., Utica horizon of the Cincinnati group, Kentucky.

From the preceding classifications we learn that *Escharopora* began in the "Birdseye" or earlier, and ceased apparently in the age of the Cincinnati group—strictly speaking, in the middle division of that formation. True *Ptilodictya* is first met with in the upper beds of that group of rocks, and continues with varying representation up into the Lower Devonian.

ESCHAROPORA ANGULARIS *n. sp.*

PLATE XII, FIGS. 1-4, 30 and 31.

Zoarium simple, falciform, curved, 10 to 30 mm. or more in length, 2 to 9 mm. wide; articulating base pointed, with comparatively a small part of the extremity solid and striated. Zoœcial apertures polygonal, commonly hexagonal, arranged in transverse and diagonally intersecting series, the first predominating, and both less regular than usual for the genus. Here and there the presence of one or more small cells (?abortive zoœcia) may cause considerable interruption in the ordinary arrangement. On an average nineteen or twenty apertures in 5 mm. diagonally, and nine or ten in 2 mm. transversely. Walls very thin, the thickness about equal on all sides. Non-poriferous margin very inconspicuous.

Of internal characters the most striking are (1) the unusual tenuity of the walls, and (2) the erectness of the zoœcial tubes. Tangential sections greatly resemble such sections of certain *Trepostomata* (*e. g. Monotrypella quadrata* Rominger, sp.).

The comparatively irregular arrangement of the zoœcial apertures, their angular form, and the fact that their also thinner walls commonly form hexagonal or polygonal instead of subrhomboidal spaces, distinguishes this species from *E. falciformis* (*Ptilodictya falciformis* Nicholson) of the Cincinnati group. In other respects, especially in the shape of the zoarium, the two species resemble each other very greatly. Embedded in the limestone, with only a portion of the surface exposed, *E. angularis* might very easily be mistaken for some monticuliporoid. Not so, however, with *E. subrecta*, which abounds at the same localities though not at the same geological horizon. The zoarium of the latter is always straighter, and the zoœcial apertures quite different.

Formation and locality.—Rare in the Trenton limestone at Minneapolis, Minnesota.

ESCHAROPORA SUBRECTA *Ulrich.*

PLATE XII, FIGS. 5-29.

Ptilodictya subrecta ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 63.

Zoarium simple, flattened, straight or slightly curved, 12 to 40 mm. or more long, 1.3 to 9.0 mm. wide, the two faces obscurely ridge-shaped, or evenly convex. Average size about 25 mm. long, and 2.5 mm. wide in the upper half. Greatest thickness varying with age from 0.6 to 1.5 mm. Lower half tapering gradually to to the pointed basal articulating extremity, the latter often turning a little to one side, subcylindrical, finely striated longitudinally, the grooves widening slowly upward till they graduate into the elongate, confluent zoœcial apertures. Arrangement and appearance of zoœcial apertures and interspaces varying with age. In young examples, or those less than 25 mm. in length, and these seem to be by far the most abundant, the surface appears as in figures 18 to 21. In these the zoœcial apertures over the entire surface, excepting near the base and along the edges, are elongate elliptical, sometimes almost acute at the ends, and arranged between alternately converging and receding ridges, which, failing to close around the ends of the apertures, permit confluence between them through a narrow channel. The result is a very pronounced longitudinal arrangement, though the diagonal rows, and sometimes the transverse as well, are scarcely less evident and regular. Measuring lengthwise there are about eleven zoœcial apertures in 5 mm.; diagonally nine or ten in 2.5 mm.; transversely six of the central rows in 1 mm. The marginal rows are always larger, and occasionally have the oblique character shown in fig. 21. In specimens 25 mm. long the upper extremity will already indicate the changes that took place in later growth. The shallow channel connecting the zoœcial apertures is gradually lost through the closer convergence of the enclosing ridges, till at last we have a simple ridge-like separating wall as shown in figs. 23 and 24. These figures show further that the apertures are now wider, with only five in 1 mm. transversely, and of subrhomboidal or hexagonal form. The increased width is accounted for partly by the loss of the channels, and the remainder by the increased circumference of the zoarium. The largest specimens usually exhibit a central row of small monticules. In some there are two irregularly alternating rows, while in the fragmentary original of fig. 17, there are three rows. The last specimen is peculiar also in having an arrangement of the zoœcial apertures foreshadowing true *Ptilodictya*, namely, oblique "pinnate" rows predominate on the spaces between the outer monticules and the edges of the frond, yet over the central part of the surface the usual diagonally intersecting series prevail.

All the changes produced by age are chiefly apparent in the upper half of the zoarium, the appearance of the early stages being more or less preserved in the basal portions. Still, very old and thick examples, like the original of figs. 15 and 22, are likely to develope mesopores here in place of mere channels between the zoœcial apertures.

Of internal characters shown in the excellent and instructive sections illustrated, I wish to point out (1) the elongate form of the primitive cell, (2) its shape just before being roofed over to form the primitive aperture, and (3) the two at first distinct then coalescing lines in the transverse interspaces. (See upper parts of figs. 25 and26.)

In 1886 I believed this species to be a close relative and, perhaps, the western representative of Hall's *E. recta.* Since making my final investigations, with augmented material in all stages of growth, much of it in an excellent state of preservation, I find that the relationship is more remote than it seemed at first. Although I have not had an opportunity of examining authentic examples of *E. recta,* Hall's original figures are sufficiently diagnostic to warrant us in saying that the New York species has zoœcial apertures agreeing both in shape and arrangement with those of *E. falciformis* (Nicholson) and the closely related *E. acuminata* (James). The last is the form referred to (*loc. cit.*) as occurring "in the lower beds of the Cincinnati group (Utica shale ?) in Ohio." The form mentioned at the same time as found in Tennessee ("Glade" limestone) greatly resembles *E. acuminata,* but as I have not yet examined its interior structure, I cannot say that it is really the same. Whatever it may turn out to be I am satisfied that it is distinct from *E. subrecta.* Comparing ordinary examples of the Minnesota species with any of these forms, indeed with all of the known simple species of the genus, we find that in none of the latter, save for a short distance above the pointed base, are the zoœcial apertures confluent longitudinally, *i. e.* connected by narrow channels, as is the case in *E. subrecta.* Nor do any of them exhibit as much difference in the size of the marginal and central rows of apertures. Of unbranched species, *E. subrecta* is also the only one known to me in which the primitive cell assumes the peculiar claviform shape shown in figs. 25 and 26. In most of the other species, perhaps all save *E. angularis,* the hemisepta are more pronounced. These two features alone are sufficient in distinguishing thin sections of *E. subrecta.* Compared with the branching forms, we find one, and it is associated in the same beds, that agrees in many respects. This is the next described *E. confluens,* having confluent zoœcial apertures, a similar difference in the size of the marginal and central rows, and an internal structure nearer that of *E. subrecta* than any other species. But the zoœcial apertures are wider, a fact noticeable enough to enable one to distinguish the merest fragments. There is, of course, no likelihood of confusion when complete zoaria are available.

Formation and locality.—Common in the middle third of the Trenton shales at Minneapolis and other localities in the state, and Decorah, Iowa. Perhaps, also, in the lower third of the shales, but rare in these and smaller than usual. A single example collected by Mr. Charles Schuchert from the "Lower Blue beds" near Beloit, Wisconsin, seems to belong to this species.

Mus. Reg. Nos. 5929, 7558 and 7597.

Escharopora confluens *n. sp.*

PLATE XIII, FIGS. 1-12.

Zoarium branching, the smallest seen less than 25 mm. high, with the branches averaging about 2.5 mm. in width; the largest fragments indicate a hight of from 80 to 120 mm., and in these the width of the branches varies from 4 to 8 mm. The two surfaces of the branches are generally obtusely ridge-shaped, and in the largest a row of monticules, or simply clusters of large cells, occurs on the summit of the ridge. Edges thin and sharp, commonly with a coarsely striated or pitted narrow border. Through all stages, though less distinct in the oldest, the zoœcial apertures are narrow and appear to be drawn out at the ends so as to connect by means of a narrow channel. This confluent character of the zoœcial apertures is better shown and more regular in the central rows, where they are also narrower and on the whole considerably smaller than toward the margins. (See fig. 5.) In the central rows, ten in 5 mm. lengthwise; eighteen or nineteen in 5 mm. diagonally, and five and one-half in 1 mm., and ten in 2 mm. transversely; of longitudinal rows there are nineteen or twenty in 2 mm.

Tangential sections show that the base of the zoœcia, excepting those in the marginal rows, is bounded by very thin, straight, longitudinal walls, and equally thin transverse partitions. This portion of the zoœcium therefore may be described as a parallelogram, with the length and breadth respectively as four is to one. At about the middle of the hight of the primitive cell its sides have spread a little and the ends contracted in a corresponding degree. Just as the posterior half is about to be roofed over two projections from the side walls, at a points a little behind the middle, gradually converge until they meet and thereby cut off and enclose the elliptical primitive aperture. In the succeeding stages the principal change is a reduction in the size of the apertures, caused by an internal deposit. These stages are all shown in figs. 6, 7 and 8, but to insure a trustworthy idea of the internal structure of the species, they should be studied in connection with figs. 10 and 11.

Compared with associated Bryozoa, the next described *E.* (?) *limitaris* only will be found difficult to distinguish. This, however, is due chiefly to the imperfect preservation of the surface of most specimens. Good examples of the latter are quickly distinguished by the different character of the longitudinal interspaces, these being occupied by one elongated pit or two smaller ones.

The zoarium of *E. subrecta* is always strictly of the simple type, and never branches except under abnormal conditions.

Specimens of this and the following species were catalogued by me in 1886 as *Ptilodictya ramosa* Ulrich (now *Escharopora ramosa*).* Comparison with the Kentucky

*Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 102.

and Tennessee tpyes of that species was not possible before the following year, when I became satified that the Minnesota specimens were really quite different, though similar in their growth. In *E. ramosa* the zoœcial apertures are set into regularly hexagonal spaces, and are in no sense to be called "confluent."

Formation and locality.—Apparently restricted to the middle third of the Trenton shales, at Minneapolis, Minnesota. Fragments of a very similar, perhaps identical, species have been observed in the "Pierce" limestone at Murfreesboro, Tennessee.

Mus. Reg. No. 8208.

ESCHAROPORA (?) LIMITARIS, *n. sp. or var.*

PLATE XIII, FIGS. 12 and 13.

Under this name I propose to arrange a form that may well be regarded as the beginning of the branching section of the genus *Phœnopora,* Hall. I would have placed it under that genus but for the fact that I found it impossible to draw a satisfactory line between it and *E. confluens.* Ordinarily the branches of the present form are smaller and more evenly convex, their edges less sharp, and with a wider non-poriferous border than in typical *E. confluens;* but in other specimens, one in particular, the shape and general aspect of the zoarium is precisely as in the most typical examples of the species. The single constant peculiarity of *E.* (?) *limitaris* consists in the development of an elevated rim at the ends of the zoœcial apertures, causing them to lose their confluent character, and to assume a definite elliptical shape. At the same time the "channel" has been transformed into an elongated inter-apertural pit. Frequently, instead of the single long pit, the space is divided into two short ones, as in *Phœnopora wilmingtonensis,* and *P. incipiens.*

The usual appearance of the surface may be imagined when I say that it is a intermediate between the appearances represented in fig. 20, plate XII, and fig. 5, plate XIII, on the one side, and figs. 14 and 23, plate XIII, on the other.

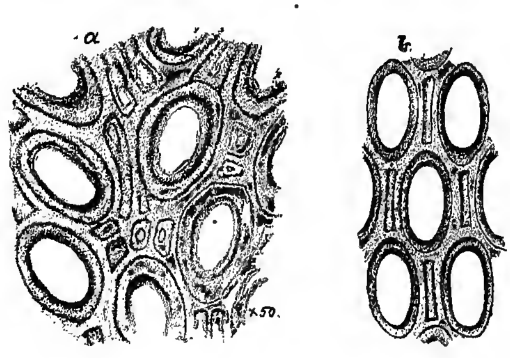


FIG. 9. *Escharopora (?) limitaris* ULRICH. *a*, small part of tangential section, x50, showing structure immediately beneath the point of bifurcation; *b*. another portion of same where the zoarial margins are parallel.

As shown in the accompanying cuts, the internal structure brought out in tangential sections is often almost exactly as in *Ph. incipiens* (plate XIII, fig. 17); other sections, however, in portions at least, show a structure more in accordance with fig. 7, plate XIII.

It is evident that *E.* (?) *limitaris* and *E. confluens* are varieties of one species, but because of their intermediate position between *Escharopora* and *Phænopora*, it is scarcely advisable to decide now which of the two names shall take the rank of a species, and which that of a variety. Such decisions should be deferred till we are better acquainted with the developmental history of fossil Bryozoa.

Formation and locality.—Not uncommon in the lowest third of the Trenton shales, at Minneapolis, Minnesota. Also in the middle third of the shales at the same locality, but less common and of more robust growth. A single specimen was observed among a lot of Bryozoa marking the lower shales, collected by Messrs. Schuchert and Scofield, near Preston, Minnesota

Mus. Reg. No. 5930.

Genus PHÆNOPORA, Hall.

Phænopora, HALL, 1852, Pal. N. Y., vol. ii, p. 46; ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v. p. 152, and 1890, Geol. Sur. Ill., vol. viii, p. 392; FOERSTE, 1887, Bull. Sci. Lab. Denison University, vol. ii, p. 157.

Zoaria bifoliate, simple or branching, the base pointed and articulating into a small basal expansion, the same as in *Ptilodictya* and *Escharopora.* Zoœcial arrangement regular, in longitudinal, diagonally intersecting and transverse rows, with either the longitudinal or the diagonal series predominant. Two mesopores behind each zoœcial aperture, one on each side, or one behind the other. Primitive cells elongate, commonly oblique or lozenge-shaped, at other times with the ends rectangular, always arranged between straight, longitudinal walls. Monticules, or mere clusters of large cells and mesopores, present when zoaria are wide enough.

Type: *Phænopora explanata* Hall, 1852, Pal. N. Y., vol. ii, p. 46.

From the above description it is obvious that the presence of the two mesopores is the only character to be relied upon in distinguishing the genus from *Escharopora* and *Ptilodictya.* The genus attains its highest development in the Clinton group, and in most of the species from that horizon the primitive cell has a peculiar oblique shape that is not seen in the Lower Silurian representatives of the genus, nor in any species of *Escharopora,* but is not uncommon among true Upper Silurian *Ptilodictya.* As might be expected, it is among the unbranched species that the greatest resemblance to *Ptilodictya* obtains. Indeed, such species as *Ph. ensiformis* Hall, and *Ph. lonsdalei* (*Ptilodictya lonsdalei* Vine) are in every respect, save in this that they possess the characteristic mesopores, precisely like narrow species of *Ptilodictya.*

In the following classification I have arranged the species in sections the same as under *Escharopora.* Except in one instance, I have not been able to obtain specimens of the European species, described mainly as *Ptilodictya,* that I suspect to belong to this genus. Under the circumstances it would not be safe to include them.

Section *a*, zoaria simple, without monticules.

Phœnopora ensiformis Hall, Clinton group, New York, Canada, Ohio and Indiana.
P. lonsdalei (*Ptilodictya lonsdalei* Vine), Wenlock shales, England.
P. tenuis Hall, Lower Helderberg group, New York.

Section *b*, zoaria simple, with monticules.

Phœnopora bipunctata (*Ptilodictya bipunctata* (Van Cleve) Hall,) Clinton group, Ohio.
P. constellata Hall, Clinton group, New York and Canada.
P. expansa Hall and Whitfield, Clinton group, Ohio.
P. punctata (*Ptilodictya punctata* Nicholson and Hinde), Clinton group, Canada.
P. superba (*Ptilodictya superba* Billings), Anticosti group, Anticosti.
P. wilmingtonensis Ulrich, Cincinnati group, Illinois.

Section *c*. zoaria branching.

Phœnopora excellens (*Ptilodictya excellens* Billings), Anticosti group, Anticosti.
P. explanata Hall, Clinton group, New York and Canada.
P. fimbriata (*Ptilodictya fimbriata* James), Clinton group, Ohio.
P. incipiens Ulrich, Trenton group, Canada and Vermont.
P. lindstrœmi Ulrich, Upper Silurian, Gotland.
P. magna (*Stictopora magna* Hall and Whitfield), Clinton group, Ohio.
P. multifida (*Stictopora multifida* (Van Cleve) Hall), Clinton group, Ohio.

Though fully convinced that some of these species are synonymous, it seemed best to retain all names until an opportunity offers to treat the genus in a monographical way.

PHÆNOPORA INCIPIENS *n. sp.*

PLATE XIII, FIGS. 14-17.

Zoarium small, dividing dichotomously at rather long intervals; basal extremity long, slender, subcylindrical, with fewer and more elongate zoœcial apertures than above the first bifurcation. Branches 1.5 to 2.0 mm. wide, compressed, rigid, edges sharp, parallel, with moderately developed striato-punctate, non-poriferous border. Zoœcia in from twelve to fifteen alternating ranges, very regularly arranged in longitudinal, diagonally intersecting and transverse rows, with respectively eleven in 5 mm., ten in 2.5 mm., and five in 1 mm. Zoœcial apertures of equal size, elliptical, enclosed in a minutely papillose rim or peristome, the latter slightly depressed at the ends, and generally in contact with each other at four points, so that with a side-light the apertures may appear as arranged between alternately converging and diverging raised lines. End interspaces elongate, depressed, commonly occupied by two mesopores, in other cases by three, and rarely, except in the marginal rows, by four or more now in double rows; always disposed in a longitudinal manner. Non-poriferous border occupied by two or more rows of mesopores.

This form is easily distinguished from all the branching Clinton group species of the genus by the longitudinal arrangement of the mesopores. It is, however, especially in its internal structure, very similar to, and perhaps a descendant of, *Escharopora* (?) *limitaris*. Still, its branches are narrower and more rigid, and there is not that difference in the size of the central and marginal rows of zoœcia that pertains to that Minnesota species.

Formation and locality.—Trenton limestone, Montreal, Canada, and Chimney Point, Vermont. Recently a fragment apparently identical with the eastern types of the species was collected at St. Paul, Minnesota, by the author, in the Galena shales.

Collectors, Mr. T. C. Curry and Prof. Henry M. Seely.

Phænopora wilmingtonensis *n. sp.*

PLATE XIII, FIGS. 22-26.

Zoarium a simple lanceolate frond, straight or slightly curved, tapering to a point below, 40 to 100 mm. or more in length, 6 to 24 mm. wide, and 1.0 to 2.5 mm. thick at the center; edges acute, non-poriferous margin inconspicuous, surfaces gently convex, sometimes a little flattened on each side of the center, exhibiting, according to the width of the frond, from one to ten rows of low monticules. The latter occur at intervals of 2 or 3 mm., are usually arranged in rather irregular longitudinal and diagonal rows, and occupied by greater or smaller aggregations of mesopores and zoœcia, the latter of slightly larger size than the average. Zoœcial apertures subcircular or ovate, arranged in regular diagonally intersecting and transverse rows; often, especially in the lower half of the zoarium, with the enclosing rim depressed at the ends, in which case they appear to be longitudinally confluent. Longitudinal interspaces depressed, generally with two small mesopores, one just in front of, the other immediately behind each aperture. Toward the center of the monticules the number of the mesopores in each interspace is gradually increased to four or more. Measuring lengthwise, about twelve apertures in a direct line 5 mm. long, and twenty-three or twenty-four of the transverse rows in the same distance; diagonally, twenty, and transversely twenty-three or twenty-four in 5 mm.

In tangential sections the base of the primitive cells is greatly elongate and bounded by subparallel sides and slightly oblique end walls. Very soon after, the anterior two-thirds is swollen and a curved hemiseptum thrown out from one side, which continues till it joins the opposite wall, thus enclosing the primitive aperture. Preceding this the walls are very thin, but now they add to their thickness by internal deposit. At the same time the aperture assumes a more rounded shape, the walls approach laterally so that each cell is, normally, in contact with six of its neighbors. Between these points there is a triangular open space or mesopore.

The walls consist, first, of the original, transversely lined (? minutely perforated) investment, and, second, of an inner laminated deposit (see fig. 25). This structure prevails in all the typical genera of the *Ptilodictyonidæ*, but, unfortunately is rarely preserved.

Every important feature noticed in vertical sections is represented in fig. 26.

When plate XIII was lithographed the specimen thereon illustrated was the only one then available. When, several months later, the remainder of my collections from Wilmington, Illinois, was unpacked, I was fortunate enough to find seven more examples, three of them with the pointed basal extremity.

The presence of mesopores distinguishes this species from Lower Silurian *Escharopora,* like *E. maculata* Ulrich, while their longitudinal arrangement serves to separate it from the unbranched Upper Silurian species of *Phænopora.*

Formation and locality.—Upper beds of the Hudson River group, at Wilmington, Illinois.

Genus ARTHROPORA, Ulrich.

Ptilodictya and *Stictopora* (part.), of several authors.
Arthropora, ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 152; S. A. MILLER, 1889, North Amer. Geol. and Pal., p. 293; ULRICH, 1890, Geol. Surv. Ill., vol. viii, p. 393.

Zoaria bushy, spreading in a plane, composed of numerous, essentially equal segments; joints simple, bifurcating, or with several short lateral branchlets, the extremities solid and rounded for articulation with succeeding segments. Zoœcial apertures elliptical, surrounded by a delicate peristome. Interspaces with one or more thread-like ridges, variously disposed, sometimes short and vermicular, at other times forming continuous longitudinal wavy lines, or ranged in a concentric manner about the apertures. Peristomes and ridges each with a row of minute papillæ. Interior with the primitive cell elongate, narrow, one or both hemisepta, and lined with minute dots (? median tubuli) between the zoœcia in the peripheral region. Mesial laminæ zigzag in transverse sections, without "median tubuli."

Type: *Arthropora shafferi* (*Stictopora shafferi* Meek). Range, from base of Trenton formation to top of Hudson River group.

This genus is closely related to *Graptodictya,* the only difference being that in the species of that genus the zoarium is continuous above the basal articulation, while in *Arthropora* it is divided into subequal joints. In certain of the internal characters, (*e. g.* the rows of interstitial dots) we are reminded of the *Rhinidictyonidæ,* but the general agreement with the *Ptilodictyonidæ,* especially in the absence of minute tubuli between the mesial laminæ, precludes all likelihood of near relationship with *Rhinidictya.*

The three species next following and *A. shafferi* (Meek) are the only species so far published of which we know positively that they belong to *Arthropora.* There are, however, at least three other distinguishable forms in the Cincinnati group of Ohio, Indiana and Kentucky, each marking a particular horizon in the group. Most of the species are abundant, but it is exceedingly rare to find any number of the segments still joined together, or lying in their original order.

ARTHROPORA SIMPLEX *Ulrich.*

PLATE XIV, FIGS. 12-21.

Arthropora simplex ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 65.

Zoarium jointed, rarely found except as isolated segments. Normally developed, the segments are narrow, more or less compressed, unbranched, straight stems, rounded and solid at each end, with sharp edges and striated non-poriferous border; 12 to 19 mm. long (average length about 18 mm.), 1.0 to 1.8 mm. wide, and always less than 1.0 mm. in thickness. The basal or primary segment is irregularly branched, and occasionally some of the succeeding segments are divided, but such divisions are evidently abnormal. A single specimen preserves several joints in their natural position. From this it appears that, as a rule, the upper extremity of each segment articulated with two succeeding segments. Basal segments thickest, sometimes nearly cylindrical, their superficial characters obscured, the peristomes and interstitial ridges thickened and the zoœcial apertures reduced in size through age. In the younger segments, and most specimens are to be so classed, the characters are as follows: zoœcia very regularly arranged in transverse and diagonally intersecting series, with five in 1 mm. transversely, and eleven or twelve in 3 mm. diagonally; twenty-four to twenty-six of the transverse rows in 5 mm. longitudinally. Zoœcial apertures elliptical, surrounded by a very thin, granose peristome. The latter is easily overlooked, strongly depressed at the sides, but elevated and prolonged at each end, in most cases not far enough to connect succeeding apertures; separating the longitudinal rows an elevated, thin, papillose, wavy ridge. In passing around the zoœcial apertures these ridges alternately diverge and converge, two coming close together, often even uniting, in the spaces between the sides of the apertures. In many segments only the raised ends of the inner depressed ring of papillæ are distinguishable. In these cases the longitudinal ridges combine in front and behind the apertures so as to produce an appearance similar to fig. 22, plate XIV.

In figures 21 *a*, *b*, *c*, I have endeavored to show all the characters of the zoœcia that are to be brought out in tangential sections. The right sides of *a* and *b* represent the structure just beneath the surface, while the left sides show it at a deeper level in the section. In 21 *c* only the primitive or prostrate portion of the zoœcia is shown.

The unbranched character of the segments of this species, as well as their greater length, will distinguish them at once from all other species of the genus.

Formation and locality.—Very abundant in the lower and middle thirds of the Trenton shales, at Minneapolis, St. Paul, Fountain and other localities in Minnesota; Decorah, Iowa.

Mus. Reg. Nos. 5933, 8075.

ANTHROPORA BIFURCATA *n. sp.*

PLATE XIV, FIGS. 22-25.

Segments small, thin, with sharp edges and rather wide non-poriferous border, the lower ones bifurcating, usually only once; so far as observed not over 8 mm. long, and from 1.2 to 1.8 mm. wide; the upper joints shorter, their length occasionally less than 5 mm., bifurcating, or with a single lobe-like projection on one or both sides. Young segments with comparatively large, ovate zoœcial apertures, not very regularly arranged in longitudinal and diagonally intersecting series, with about nine in 3 mm. lengthwise, and five in 1 mm. diagonally. Apertures enclosed in distinct granulose rims, connecting longitudinally. Interspaces depressed, sometimes with a few indistinct striæ. With age the zoœcial apertures become more circular and smaller, and the peristomes and connecting ridges thicker.

This species is related to *A. shafferi* (Meek) but differs in having only one ridge or line in the interspaces, instead of from one to four. *A. simplex* has longer and unbranched segments, while *A. reversa* has a peculiar horseshoe-shaped ridge about its zoœcial apertures.

Formation and locality.—Detached segments rather common in the Galena shales and in the upper third of the Trenton shales at St. Paul, and Cannon Falls, Minnesota. A closely allied species, perhaps it is identical, in the Trenton limestone of Kentucky, Tennessee, and Canada.

Mus. Reg. No. 8108.

ARTHROPORA REVERSA *n. sp.*

PLATE XIV, FIG. 26.

Of this species I have seen only two segments, but their superficial aspect is so distinctive that I do not hesitate in proposing a new name for them. One of these is 8 mm. long, and divides dichotomously about midway the length. The two forks are of the same strength as the lower half, averaging 1.2 mm. wide, the three extremities abrupt and tipped for articulation with the preceding and succeeding segments. The other, apparently the basal or primary segment, is pointed below trifurcately divided 4 mm. above the lower extremity, with the three branches of equal strength and the central one again divided, this time merely bifurcating, at its upper end; total length 8 mm., width about 10 mm. The zoarial growth and general aspect of the segments seems therefore to be precisely as in *A. bifurcata.*

Zoœcial apertures small, subcircular, separated from each other by spaces fully equalling their diameter; arranged in rather irregular, more or less oblique transverse series, about six in 1 mm., and in six to eight, more regular, longitudinal rows, with twelve to fourteen in 3 mm. Immediate border of apertures formed by a ring of very minute granules. This ring is depressed except at the lower end, so that it is not likely to be seen save under the most favorable circumstances. The lower end is commonly prolonged into one or two short rows of granules, perhaps extending completely across the end interspaces. The most striking peculiarity of the species is a horseshoe-shaped ridge, open below, which, in the usual state of preservation, appears to enclose the sides and upper end of each zoœcial aperture. This ridge is papillose, thick, and strongly elevated in the middle (in front of each aperture) gradually tapering to the ends. The strong elevation in front of the apertures, causing them to appear as oblique and turned backward, suggested the name *reversa.* The ends of the horseshoe ridge may be free, (see fig. 26) or they may unite with the sides of the one next beneath. Non-poriferous border rather wide, with distinct, oblique rows of papillæ.

Formation and locality.—Upper third of the Trenton shales, at St. Paul, Minnesota. Recent collections made at this locality from this horizon and the overlying Galena shales afford a considerable number of detached segments agreeing in all essential features with the described types of the species.

Mus. Reg. No. 8109.

Genus STICTOPORELLA, Ulrich.

Stictoporella, ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, pp. 152 and 169; and 1890, Geol Surv. Ill., vol. viii, p. 394; VINE, 1884, Fourth Rep. Brit. Assoc. on Foss. Poly., p. 44; MILLER, 1889, North Amer. Geol. and Pal., p. 325.

Zoaria bifoliate, growing from a broad basal expansion into narrow, parallel-margined, branching stipes, simple leaf-like fronds, or cribrose expansions. Zoœcia with the primitive portion tubular, unusually long, generally without hemisepta, the inferior one only occasionally present. Apertures elliptical, placed at the bottom of a sloping area, the latter usually polygonal. More or less numerous, thick-walled, untabulated mesopores occur between the zoœcial apertures and line the zoarial margins. Maculæ, composed of clustered mesopores, and sometimes of zoœcial apertures of larger size than the average, commonly scattered over the surface of the frondescent species.

Tangential sections of favorably preserved specimens show that both the zoœcia and mesopores are separated from each other by a sharply defined line of minute pore-like dots. True median tubuli and diaphragms wanting.

Type: *S. interstincta* Ulrich. Range, Lower Trenton to Chester.

For remarks on the relations and systematic position of this genus see *ante* p. 162.

The range of zoarial diversity allowed in this genus is unusually comprehensive. Perhaps it is too much so, and that the cribrose species ought to be distinguished generically. Most certainly they look very different from the others and are, I grant, as much entitled to generic separation as *Clathropora*, Hall, *Coscinium*, Keyserling, and other genera that might be mentioned, all differing from related genera chiefly or solely in the cribrose character of the zoaria. Though inclined to favor a separation, I have decided to leave them with *Stictoporella* for the present.

CLASSIFICATION OF AMERICAN SPECIES.

Section *a:* zoarium branching.

Stictoporella interstincta Ulrich, Utica horizon, Cincinnati group, Kentucky.
S. angularis Ulrich, base of Trenton shales, Minnesota.
S. angularis var. intermedia Ulrich, base of Trenton shales, Minnesota.
S. dumosa Ulrich, Trenton shales, Minnesota.
S. rigida Ulrich, Trenton shales, Minnesota.

Section *b:* zoarium wide, leaf-like, with maculæ.

Stictoporella frondifera Ulrich, base of Trenton shales, Minnesota.
S. ? basalis Ulrich, Keokuk group, Illinois, Iowa.
S. ? undulata Ulrich, Chester group, Kentucky, Illinois.

Section *c:* zoarium cribrose.

Stictoporella cribrosa Ulrich, middle Trenton shales, Minnesota.
? Clathropora flabellata Hall, Trenton, Wisconsin.
Stictoporella proavia (*Coscinium proavium* Billings, ? Eichwald), Trenton, Canada.
S. n. sp.(with smaller meshes than in the others), "Pierce" limestone, Tennessee.

STICTOPORELLA RIGIDA *Ulrich.*

PLATE XI, FIGS. 20 and 21.

Sticloporella rigida ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 188.

Original description: "Zoarium a narrow branching, bifoliar stipe. Branches flattened, 1.0 mm. or a litle more wide, with straight parallel and sharp margins, acutely elliptical in cross-section. Zoœcia in seven to nine or ten rows on each face, their apertures arranged in very regular longitudinal and diagonally intersecting series, with sixteen 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 zoœcial 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 neat species is near *S. interstincta* from the Utica horizon of the Hudson River group, but has somewhat narrower branches, fewer mesopores, and much thinner walls. In *S. angularis* the walls are much thicker, branches wider, sloping areas about the zoœcial apertures polygonal, and the mesopores less numerous and irregularly distributed. *S. dumosa* has wider and oftener divided branches.

Formation and locality.—Rare in the lower part of the upper third of the Trenton shales, at St. Paul, Cannon Falls, and near Fountain, Minnesota.

Stictoporella dumosa *n. sp.*

(Not figured.)

Zoarium forming bushy masses, as much as 100 mm. in diameter and 50 mm. high, consisting of very irregularly divided, free or coalescing, small branches, 1.5 to 2.0 mm. in width, and usually less than 0.5 mm. in thickness. Zoœcial apertures subcircular or elliptical, set into rather wide sloping areas of polygonal or rounded outline, the shape depending upon the number of mesopores present. Arrangement rather irregular; occasionally longitudinal rows, with the mesopores between the ends of the zoœcial apertures, prevail, in which case the surface appearance is much the same as in *S. rigida*. More commonly, however, a diagonal arrangement predominates, with the mesopores distributed more at random. In these, especially when the mesopores happen to be fewer than usual, the general appearance is much more like that of *S. angularis*. Where the arrangement is the most regular there are ten or eleven zoœcial apertures in 3 mm. diagonally, and about eight in the same space longitudinally. Apertures often closed by a slightly convex plate, in which a minute subcentral perforation may be detected. Walls ridge-shaped, generally wider than the diameter of the zoœcial apertures. Mesopores varying in number; sometimes a fragment will show about one only to each zoœcium, while others may have them three or four times as numerous. Edges sharp, generally exhibiting two or three rows of mesopores.

Internal structure, especially in transverse and vertical sections, very similar to that of *S. cribrosa*. In tangential sections the mesopores are not as distinct, and the divisional line between the zoœcia less sharply defined, than in similar sections of that species.

As a rule, I do not favor descriptions of species without illustrations, but in this case the form is so easily recognized that the omission may be pardoned. Compared with *S. angularis* it is distinguished by its more irregular and stronger growth, and more abundant mesopores. The occasional inosculation of the branches points to a relationship with *S. cribrosa,* and this is further evidenced by the agreement in their internal structure. The position of the species is probably intermediate between *S. angularis* and *S. cribrosa.*

Formation and locality.—Upper third of the Trenton shales at St. Paul, Minnesota.

Mus. Reg. No. 8110.

STICTOPORELLA ANGULARIS *Ulrich.*

PLATE XI, FIGS. 1-3, 6, and 8-11.

Stictoporella angularis ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 71.

Zoarium branching dichotomously at intervals varying from 4 to 10 mm.; branches more or less compressed, 1.5 to 3.0 mm. wide, 0.7 to 2.0 mm. thick, with sharp or narrowly rounded, subparallel edges. Zoœcial apertures small, subcircular, set into wide sloping polygonal areas, with the subrhomboidal and hexagonal shapes commonest. Walls ridge-shaped, angular in the middle, their thickness usually greater than the diameter of the apertures. Zoœcial apertures arranged in moderately regular curved diagonally intersecting series, nine in 2.5 mm. When longitudinal rows are to be made out (as in upper part of fig. 6) six are to be counted in the same space lengthwise. Mesopores comparatively few, small, sometimes appearing to be absent entirely on parts of the central three-fifths of the surface, while for some distance above or beneath such a spot they may occur regularly one to each zoœcium. Near the margins, however, some are always present, with one and occasonally two rows bordering the edges.

In tangential sections, showing the structure in the peripheral part of the zoarium, the zoœcial cavity is ovate, in old examples sometimes nearly closed by internal deposits of sclerenchyma, the interspaces always thick enough to separate the cells by a distance greater than their diameter. Boundary line between the zoœcia and mesopores sharply defined, consisting of a crowded row of very minute, pore-like dots. These, however, are not recognizable except in the most favorably preserved specimens. Mesopores few, here completely filled with laminated sclerenchyma.

In vertical sections the thin-walled prostrate part of the zoœcial tube is long, but, as is usual in this genus, this portion of the section appears irregular. Hemisepta absent. In turning to the surface the tube bends abruptly, and at once the walls become very thick and marked with ʌ-shaped lines representing the sloping areas about the apertures at previous stages of growth.

The angularity of the zoœcia, together with the unusual paucity of the mesopores, distinguishes this species from *S. interstincta, S. rigida, S. dumosa* and *S. cribrosa.*

The broad, maculose zoaria of *S. frondifera* are not likely to be confounded, although the two species are undoubtedly closely related. The following variety is good evidence of that.

Formation and locality—Not uncommon in the lower third of the Trenton shales, at Minneapols, St. Paul, and several localities in Goodhue and Filmore counties, Minnesota.

Mus. Reg. Nos. 5943. 7617.

Stictoporella angularis, var. intermedia *n. var.*

PLATE XI, FIGS. 4, 5 and 7.

This name is proposed provisionally for a form that is common at several localities in Filmore county, but rare in the more northern exposures of the same beds. It differs from typical *S. angularis*, with which it is often associated, in forming wide, irregular branches, the growth and size being in many instances precisely as in the branching form of *S. frondifera.* At intervals the surface presents clusters of zoœcia with thinner walls and larger apertures than usual. The mesopores are very few, in most cases restricted to the center of the clusters mentioned. Here they may form aggregations, but these are never, as far as observed, so extensive as in *S. frondifera* One or two rows of them are also commonly present at the rounded margins of the branches.

In having very few mesopores the variety agrees with *S. angularis*, while in its wide branches and general aspect it is like *S. frondifera.* The name *intermedia* alludes to its position between those species.

Formation and locality.—Rare near the base of the Trenton shales, at Minneapolis, but common in the same beds near Fountain, Lanesboro and Preston, all localities in Minnesota; also at Decorah, Iowa

Mus. Reg. Nos. 7597, 7599, 7984.

Stictoporella frondifera *Ulrich.*

PLATE XI, FIGS. 12-19.

Stictoporella frondifera Ulrich, 1886. Fourteenth Ann. Rept. Geol. Nat. Hist. Surv. Minn., p. 72.

Zoarium consisting of broad, irregularly branching, flabellate or undulate expansions, 1 or 2 mm. in thickness, the whole attaining a hight of from 50 to 100 mm. Edges rounded, with small pits (mesopores) in two or more rows. Surface with conspicuous maculæ consisting of greater or lesser aggregations of mesopores, sometimes a hundred and more, generally about fifty or less. These maculæ are from 3 to 5 mm. apart, sometimes arranged in rows, but oftener their distribution is decidedly irregular. Between them the surface is occupied by the rounded zoœcial apertures and mesopores, the latter small and unequally distributed, varying in number from one, two, or even three to each of the former. Walls ridge-shaped, thick, usually nearly equalling the diameter of the zoœcial apertures. Arrangement variable, rather irregular, generally in diagonally intersecting series, with from fifteen to eighteen, but averaging sixteen in 5 mm.

Internal structure, as shown in thin sections, very similar to that of *S. angularis*, the only differences noticed resulting from the much greater development of mesopores.

The much greater abundance of mesopores distinguishes this species from *S. angularis*, var. *intermedia*, while the frondescent habit of its zoarium separates it from all the other Lower Silurian species of the genus. Associated in the same strata are *Pachydictya foliata* and *Phyllodictya frondosa ?*, two bifoliate species likewise characterized by foliaceous zoaria. In other respects, however, they differ so obviously from *S. frondifera*, that detailed comparisons are rendered unnecessary.

Formation and locality.—Rather abundant in the lower beds of the Trenton shales, at Minneapolis, St. Paul, Preston, near Fountain, and other localities in the state where this horizon is exposed.

Mus. Reg. Nos. 5945, 5947, 7650.

STICTOPORELLA CRIBROSA *Ulrich.*

PLATE X, FIGS. 21-25; PLATE XI, FIGS. 22 and 23.

Stictoporella? cribrosa ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 69.

Zoarium growing from a small expanded basal attachment into thin erect fronds, perhaps 50 mm. in diameter, composed of branches that inosculate at short intervals till there is produced a broad expansion perforated at more or less regular intervals by circular or elliptical fenestrules. Both sides of frond celluliferous, consisting of two equal layers of cells grown together back to back in the manner usual with bifoliate Bryozoa. Fenestrules elliptical, sometimes circular, varying greatly; the average size about 1.3 mm. by 1.8 mm., or less than the width of the branches; but the same frond may show extremes like 1 mm. and less, and 3.5 mm. Their arrangement is therefore more or less irregular, and taking other cribrose species of the genus into consideration, this irregularity in the size and distribution of the fenestrules is to be considered as a characteristic of the present species. Width of branches generally 2.0 mm. or 2.5 mm. but varying between the extremes of 1.5 mm. and 3.1 mm. Zoœcial apertures small, subcircular or elliptical, the average size about 0.1 mm. by 0.12 mm., set into sharply defined, polygonal or rounded, sloping areas, about nine in 2.5 mm. Mesopores small, numerous, often completely isolating the zoœcia. Generally, however, the latter are in contact with each other at limited points. Around the fenestrules there is a band, 0.5 mm. or less wide, occupied solely by mesopores. As in other species of the genus the zoœcial apertures are often closed by a convex plate, with or without a minute subcentral perforation.

Tangential sections show that the polygonal boundary of the zoœcia is marked by a dark line, which under favorable preservation will probably consist of a row of exceedingly minute pore-like dots. Visceral cavity ovate or subcircular, generally of less width than the walls. Mesopores numerous, of irregular shape and unequal dimensions, often completely filled, or only preserving a very small central cavity.

Vertical sections show that the divisional laminæ are somewhat flexuous, the tubes at first thin-walled and prostrate, overlapping each other for some distance, that they subsequently bend abruptly outward, and that their walls at the same time are much thickened and marked with oblique lines parallel with the form of the apertures. The mesopores appear as narrow open spaces when not entirely filled by the secondary deposit of sclerenchyma. Diaphragms and hemisepta wanting.

The Canadian Trenton limestone species identified by Billings with Eichwald's *Coscinum proavium*, is closely related to *S. cribrosa*, but differs in having narrower branches, subequal and more regularly disposed fenestrules, and less numerous mesopores. Another cribrose species, but in every respect smaller than these, occurs in the "Pierce" limestones at Murfreesboro, Tennessee. Still another Lower Silurian bryozoan with inosculating branches has been described by Hall from the Trenton rocks of northern Wisconsin.* He named it *Clathropora flabellata*, but both the description and figures are entirely inadequate for anything like satisfactory identification. It may belong to *Clathopora*, but *Stictoporella* is more likely to be right. Then again it is not impossible that it is a *Coscinella* or even a *Coscinum*, since in all of these paleozoic genera the zoarium is cribrose. Compared with the characters shown in Hall's figures, it is evident that he had before him a more robust species, with branches and fenestrules much larger than in *S. cribrosa*.

Formation and locality.—Abundant in the middle third of the Trenton shales at Minneapolis and St. Paul, Minnesota. The species seems to be restricted to this horizon.

Family ARTHROSTYLLIDÆ, Ulrich.

This interesting family of small Bryozoa is strongly represented in the Lower Silurian rocks of Minnesota. On account of the minute proportions of most of them their dismembered zoaria are generally to be found only by searching the surface of the slabs of fossiliferous limestone that occur so abundantly in certain parts of the Trenton shales. These are often full of the separated joints. The most satisfactory

*Foster and Whitney's Report, vol. 2, p. 207, 1851.

specimens, however, are those which are obtained by picking over the residue of washings of the shales themselves. These are better, not only because they can be studied from all sides, but because their preservation is, in most cases, more favorable.

Unfortunately, I had neither the time nor the opportunity of making extensive washings of shales in Minnesota, and that method of collecting was employed to only a very limited extent. Here and there a pound or two of unusually rich clay was carried away and washed during leisure moments after my return home. One of these packets proved to contain so many interesting things, and withal was so rich in individuals, that it deserves mention. The shale was from the lower part of the Galena shales, which, according to my reckoning, is the exact equivalent of the Trenton limestone of New York. After washing away less than half its bulk nearly two-thirds of the residue consisted of good fossils, of which the larger ones, mainly species of *Prasopora, Homotrypa, Callopora, Constellaria, Eridotrypa* and some *Brachiopoda,* were separated by sifting the finer material away from them. A large proportion of this fine material consisted of small fossils, among them five or six species of *Ostracoda,* (most of them described in this volume as new) and at least eleven species of small Bryozoa. Of the latter eight belong to the family under consideration, two of them being species of *Arthroclema,* three of *Helopora,* and three of *Nematopora.*

The jointed character of the zoarium is the most conspicuous and perhaps also the most important feature of the family. It is well shown in all the genera except *Nematopora,* in which articulation occurs only at the basal extremity, the zoarium above the base being a dichotomously dividing, continuous stem. In *Helopora,* Hall, *Sceptropora* and *Arthrostylus,* the segments are simple and terminally joined together, and doubtlessly formed bushy zoaria. But in *Arthroclema,* Billings, the zoarium forms a more or less plumose expansion, divisible into numerous primary, secondary and tertiary segments, those of the first and second order being connected terminally and ranged in straight lines. A deep socket occurs on one or two opposite sides of each of the strong joints of the primary series and a shallow one in most of those of the smaller secondary set, in which respectively the first of the series of the second and third order is inserted.

The zoœcia are arranged in a radial manner around a central axis and, excepting *Arthrostylus* in which one side is marked with longitudinal striæ only, open on all sides of the subcylindrical segments. In transverse sections the primitive portion of the zoœcia is wedge-shaped, but in longitudinal sections they often appear tubular. The length of the tubes depends very largely upon the diameter of the segment, since all of them reach the central axis. It is evident that the obliquity of the tubes also has something to do with their relative lengths. They are, however, not to be considered tubular in the sense attaching to that term when applied to the *Cyclostomata*. On the contrary they are no more so than are the zoœcia of the most typical *Rhinidictyonidæ*. In tangential sections they are oblong-quadrate or hexagonal in outline. Hemisepta have not been observed, but rows of minute tubuli occur between the walls of adjoining zoœcia and sometimes in the longitudinal interspaces in the vestibular region. A minute tube is also to be detected running from end to end through the axis of the segments.

Respecting the position of the family the jointed character of the zoaria leads us to look for its relationship first with the similarly constructed *Cellariidæ*. The latter embraces living forms chiefly, and of many of these I have secured specimens, so that I am now in a position to speak intelligently upon their characters, as compared with paleozoic forms. I would be glad to do this here were it not that I would thereby interfere with my plans for a general work on inter-relation of bryozoan types. It will probably be sufficient to say that the two families are distinguishable, and that the relationship between them, if any exists, is almost certainly less intimate than that between the *Arthrostylidæ* and *Rhinidictyonidæ*.

Aside from the wedge-shaped form of the primitive cells in the *Arthrostylidæ*, which it is evident resulted necessarily from their radial arrangement about a linear central axis, they are precisely like those of true *Rhinidictya*. They agree also in possessing median tubuli between the walls of adjoining zoœcia. Then again I am convinced that the minute axial tube of the *Arthrostylidæ* is functionally identical with the median tubuli between the mesial laminæ that are such a characteristic mark of the *Rhinidictyonidæ*. The jointed character of the zoarium even, is not unknown in the latter since it pertains to *Dicranopora*, Ulrich, a genus that in all other respects is precisely like *Rhinidictya*. Really, I find only one structural difference between the two families, and that is that while the zoœcia in the *Rhinidictyonidæ* are arranged so as to form bifoliate zoaria—in other words, are disposed in two equal expansions grown together back to back, they are arranged radially around a central axis, forming subcylindrical zoaria, in the *Arthrostylidæ*.

Genus ARTHROSTYLUS, Ulrich.

Arthronema, ULRICH, 1882. Jour. Cin. Soc. Nat. Hist., vol. v, pp. 157 and 160 (not ESCHSCHOLTZ, who used the name for a genus of Colpodea).

Arthrostylus, ULRICH, 1888. Amer. Geologist, vol. i, p. 230; 1890, Jour. Cin. Soc. Nat. Hist., vol, xii, p. 188; 1890, Ill. Geol. Sur., vol. viii, p. 400.

Zoaria bushy, branching dichotomously, the whole consisting of numerous, exceedingly slender, subquadrate, equal segments, joined to each other by terminal articulation. Zoœcia arranged in three (perhaps more) rows, usually between longitudinal ridges; the fourth face, commonly the widest, with longitudinal striæ only.

Type: *Arthronema tenue* Ulrich (*Helopora tenuis* James), of the Utica horizon of the Cincinnati group. (Jour. Cin. Soc. Nat. Hist., vol. v. p. 160, 1882.) The lower fig. 16 on Plate III, represents a transverse section of this species. It should have been been numbered 16*a*.

Besides the type species only three others are known to have the characters demanded by this genus. Two of these are from the Trenton shales of Minnesota, and are next described. The third species, *A. curtus* Ulrich, from the Hudson River rocks of Ohio, is still a little doubtful, no further material having been found to throw light upon the rather imperfect originals of the species.

ARTHROSTYLUS CONJUNCTUS *Ulrich.*

PLATE III, FIGS. 13 and 14.

Arthrostylus conjunctus ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 189.

Original description. "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 zoœcial openings on three sides, the fourth being without them, but marked instead with four parallel longitudinal striæ. Zoœcial 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 zoœcial 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-celliferous side narrower and with fewer striæ, causing transverse sections to be more nearly square. The *A. obliquus* differs in having oblique zoœcial apertures."

Formation and locality.—Rare near the base of the Trenton shales, near Fountain, Minnesota. In the original description the locality is given, inadvertently, as Minneapolis.

ARTHROSTYLUS OBLIQUUS *Ulrich.*

PLATE III, FIGS. 15 and 16.

Arthrostylus obliquus ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 190.

Original description: "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. Zoœcia in three rows, occupying as many faces of the segment, the fourth side with three longitudinal striæ, and no zoœcia. Profile of a segment in an obverse or reverse view, wavy on both sides; in a lateral view only on one side.

"Zoœcial 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 zoœcial aperture is flanked on each side by the prolonged lateral borders of the aperture. No ridge between the lateral and central row of the zoœcia.

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

Formation and locality.—Trenton shales, Minneapolis, Minnesota; rare.

Genus HELOPORA, Hall.

Helopora, HALL, 1852, Pal. N. Y.. vol. ii, p. 44; BILLINGS, 1866, (part.) Cata. Sil. Foss. Isl. Antic., p. 36; ULRICH, 1888, The Amer. Geologist, vol. i. No. 4, p. 231, 1890, Jour. Cin. Soc. Nat. Hist., vol. xii, p. 191, and 1890, Geol. Surv. Ill., vol. viii, pp. 401 and 642.

Zoaria consisting of numerous, subequal, small, cylindrical segments, articulating terminally, poriferous on all sides. Zoœcial tubes somewhat oblique, geniculated or proceeding to the surface in a straight line. Apertures slightly oblique or appearing direct, suboval, arranged in diagonally intersecting series (section *a*) or between more or less well defined longitudinal ridges (section *b*). In section *a* the apertures are usually without a peristome, but an acanthopore occurs immediately beneath each. In section *b* the acanthopores are wanting, but a peristome, generally incomplete and prominently elevated posteriorly, is present. Axial tube very slender.

Type: *A. fragilis* Hall, a common fossil of the Clinton group.

As is indicated above, this genus may be divided into two sections. These were noted in my previous work on the genus (*loc. cit.*) and in one of them I express the opinion that, when these fossils are better understood, these two sections will probably be separated generically. Although the study of the genus, necessitated by the present work, has strengthened this opinion, I am not yet ready to make the separation. Still, I shall go a step farther here and follow the practice adopted in treating many of the preceding genera. As in those cases I believe this non-committal division of the species into sections will suffice until we are in a position to work up the genus monographically. Except in that way it is not only difficult but almost impossible to distinguish nearly related genera in a fully satisfactory manner.

Section *a* embraces the species which agree nearest with the type of the genus, and all of them, as far as known, belong to Upper Silurian rocks (including the Anticosti group). They are distinguished from the species of section *b* (1) by the presence of acanthopores, one of which is commonly situated in each end space ; (2) the absence of longitudinal ridges and inter-apertural striæ ; (3) the predominance of the diagonal arrangement of the zoœcial apertures ; (4) the absence of a peristome, the interspaces being highest midway below the zoœcial apertures and sloping into them, and (5) the lesser separation of the zoœcial apertures longitudinally.

Under section *a* I would place *H. fragilis* Hall, from the Clinton of New York, Canada, and probably Ohio ; *H. bellula, H. armata,* and *H. nodosa,* three species described by Billings from the Anticosti group, and *H. lindstrœmi* Ulrich, from the Upper Silurian of the island of Gotland.

Section *b* differs from the typical section (1) by the absence of acanthopores; (2) the presence of straight or wavy ridges and minor striations of the surface; (3) the predominance of the longitudinal and transverse arrangement of the zoœcial apertures ; (4) the prominence of the zoœcial apertures, especially at the inferior side, and (5) in the more ornamental appearance of the segments resulting from the peculiarities noted.

Helopora spiniformis, originally described by me as *Arthroclema spiniforme* (Jour. Cin. Soc. Nat. Hist., vol v, p. 161, 1882), may well be accepted as the type of this section. This species is fairly abundant on slabs of "Glade" limestones, at Lebanon, La Vergne, and other localities in Tennessee. Figs. 4, 5 and 6, on plate III, introduced chiefly for comparison with *H. divaricata,* illustrate its principal characters. Segments of apparently the same species were collected also in the lower limestones at Dixon, Illinois.

All the other known Lower Silurian species referred to the genus must be arranged in section *b*. These are *H. quadrata,* n. sp., *H. mucronata* Ulrich, and *H.* (?) sp. undet., from the Galena shales of Minnesota, the last two with rather striking resemblances to certain Cylostomata ; *H. harrisi* James, *H. elegans,* n. sp., and *H. imbricata* Ulrich, from the upper beds of the Cincinnati group of Ohio and Illinois ; and *H. alternata* Ulrich, from the Trenton shales of Minnesota. The last represents a peculiar type of the section that is again met with, but less strongly expressed in the new species *H. elegans*.

As is to be expected, it is in section *b* that *Helopora* most nearly approaches the other genera of the family. The species of section *a* represent a further differentiation of the type. Comparing the former with *Arthroclema* we note a general agreement of structure, which, if we knew nothing of the segments of the primary and secondary order of that genus, might really be said to amount to identity. But we do know that the zoarial combination of the segments in *Arthroclema* is by both terminal and lateral articulation, while in *Helopora* they unite at their ends only. The difficulties, therefore, which we may experience in correctly classifying some of the dismembered segments, are not at all encountered when we deal with complete zoaria. Even granting that the latter condition is exceedingly rare, the trouble of discriminating between the isolated segments of the two genera is not of very common occurrence, because it is restricted to those of the third order of *Arthroclema*, those of the primary and secondary set being easily distinguished from *Helopora* by the lateral articular socket. In practice I think we are nearly safe under this working rule: When of a number of isolated segments occurring on slabs of rock or in the residue of shale washings, none have lateral sockets, it is safe to classify them as *Helopora*, providing, of course, that they agree with that genus in other respects. When, however, one or more of them possess such sockets, it is to be recommended that the investigator determine the three sets of segments of the *Arthroclema* before he classifies any of them as *Helopora*.

Of the remaining genera of the family, *Sceptropora* is distinguished by the wide expansion or swelling of the upper half of the segments; *Arthrostylus* in having one side simply striated and without zoœcial apertures, and *Nematopora* by its branching zoaria and the absence of joints above the basal articulation. The placing of such species with *Helopora*, by Billings, was an error that I am convinced he would not have committed had he known that *Helopora* originally consisted of numerous subequal segments joined together into bushy zoaria.

HELOPORA DIVARICATA *Ulrich.*

PLATE III, FIGS. 1-3.

Helopora divaricata ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 59.

Zoarium jointed; segments about 7.0 mm. long, obtuse at both extremities, subcylindrical, polygonal in cross-section, the number of the angles and corresponding rows of zoœcial apertures six, seven or eight. Their diameter varies with age and according to the number of zoœcia contained from 0.5 to 0.9 mm. Zoœcial apertures comparatively large, oblique, ovate, seeming to widen anteriorly, arranged in troughs between strong longitudinal ridges, twelve in 5 mm. lengthwise and generally in regular transverse rows. Posterior border of apertures thick, prominent, sloping backward into the aperture next below. This border is continued upon the sides of the zoœcial aperture as two diverging ridges which extend on each side to the summit of the longitudinal keels where they meet with similar ridges from the adjoining rows. These divaricating ridges cause the strong vertical keels to appear as being marked by a succession of narrow $\wedge$-shaped furrows and ridges. Occasionally, and this is true more especially of the young and slender segments, the rounded posterior slope is divided by a central furrow into two small ridges, the same as in *H. spiniformis* and *H. mucronata.*

Except the transverse section figured on plate III, the thin sections prepared of this species are not satisfactory. As far as they go it appears that the internal structure is not materially different from that of *H. spiniformis*, (see plate III, figs. 5 and 6) to which species it is closely related. In *H. divaricata* the zoœcial apertures are wider, as are also the troughs into which they open, whilst the vertical ridges which separate the rows of zoœcia are always a more pronounced feature than in *H. spiniformis.* When segments of the two species having the same diameter are compared, those of the latter species will be found to have at least one more row of zoœcia, and to be more nearly cylindrical. With age the angles become entirely effaced, the zoœcial apertures relatively smaller than shown in my figures, all the interspaces nearly on a level, and the striation almost equal throughout. The lower extremity of the segments of *H. spiniformis* also are always more pointed than in *H. divaricata.*

Formation and locality.—Rather rare in the lower third of the Trenton shales, at Minneapolis, Minnesota.

Mus. Reg. No. 5928.

HELOPORA ALTERNATA *Ulrich.*

PLATE III, FIG. 9.

Helopora alternata Ulrich, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 192.

Segments exceedingly slender, slightly curved, about 5.0 mm. long, and scarcely 0.25 mm. in diameter; lower extremity obtusely pointed, the upper rounded. Zoœcial apertures oval, nearly direct, comparatively large, about 0.13 mm. in length, arranged alternately, four in each cycle, twelve cycles in 2.5 mm., and twelve or thirteen in a direct line 5 mm. long. Interspaces rather thin, generally appearing to be simply rounded, but, with the light coming from the side, two narrow furrows, passing in a sinuous manner between the apertures, are to be seen. The result is thin peristomes united longitudinally by a thin connecting ridge.

The exceeding delicacy of the segments and the comparatively large size and alternate arrangement of the zoœcial apertures of this species causes it to be distinguished without difficulty from all known Trenton forms.

Formation and locality.—Rare at the base of the middle third of the Trenton shales, Minneapolis, Minnesota.

Helopora mucronata *Ulrich.*

PLATE III, FIG. 10.

Helopora mucronata Ulrich, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 192.

Segments spine-like, slightly curved, 3.5 to 4.0 mm. long, tapering downward from the truncate upper end, where the diameter is 0.6 or 0.7 mm., to the acute and finely striated basal extremity. Zoœcial apertures oblique, the inferior and lateral margins elevated, arranged longitudinally and spirally, with from six to eight forming a complete volution, and six in about 2.5 mm. lengthwise. Above each zoœcial aperture two short striæ. Obscure longitudinal ridges sometimes formed by the coalescence and continuance of the elevated lateral margins of the zoœcial apertures.

The curved and tapering form, the acute lower extremity, and the very slight development of the longitudinal ridges, distinguish this species from all the associated jointed Bryozoa, as well as from *H. divaricata* and *H. spiniformis.* None of the other species of the genus are sufficiently near to require comparisons.

Though readily distinguishable from all the known varieties of segments of the associated *Arthroclema armatum,* it may yet be shown by complete zoaria of the latter that *H. mucronata* is but another form of segment of *Arthroclema.* Until such evidence is discovered we had best leave them as at present.

Formation and locality.—Galena shales, near Cannon Falls, Minnesota, where it is associated with *Helopora quadrata, Arthroclema armatum,* and several species of *Nematopara.* Also at St. Paul.

Mus. Reg. No. 8112.

Helopora quadrata, *n. sp.*

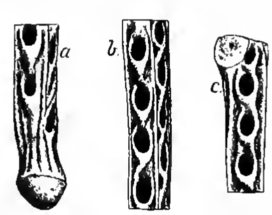


Fig. 10, *Helopora quadrata* Ulrich. Galena shales, near Cannon Falls, Minnesota. *a*, basal par of a segment; *b*, the central portion of another, and *c*, the upper extremity of a third, all x 18.

Segments very slender, quadrate in cross-section, the angles sharp, the sides each about 0.28 mm. wide; entire length unknown, none of the segments at hand being complete, probably between 5 and 6 mm.; lower end bulbous, the upper with two flattened articulating faces. Zoœcial apertures in four longitudinal rows, one on each of the concave sides; ovate, a little oblique, the inferior and lateral margins with a strong rim, produced backward, either straight or obliquely, as a sloping ridge. Zoœcial apertures separated by distances very nearly equal to their long diameter, with nine or ten in 3 mm.

This is the only species of the genus known to me having quadrate segments and only four rows of zoœcia. Fragments look a little like small pieces of *Nematopora ovalis*, an associated species, but are readily enough distinguished by their sharper angles, and the relatively much greater elevation of the posterior margin of their zoœcial apertures.

The exceeding delicacy of the segments, and their structure in general, gives them very much the appearance of species of *Arthrostylus*. But as all of the four faces are occupied uniformily each by a row of zoœcial apertures, it is evident that the species does not belong to that genus.

Formation and locality.—Comparatively rare in washings of the Galena shales, near Cannon Falls, Minnesota.

Helopora elegans, *n. sp.*

Fig. 11, *Helopora elegans* Ulrich, Cincinnati group, Blanchester, Ohio. A segment of this species of the natural size and x 18.

Segments small, subcylindrical, obtusely hexagonal in cross-sections, about 3.0 mm. long and 0.3 mm. in diameter; upper extremity truncate, the lower rounded and tapering slightly. Zoœcia in six longitudinal ranges, their apertures narrow-elliptical, slightly depressed in front, their length apart, arranged alternately in adjoining rows. Entire surface beautifully grano-striate, the striæ flexuous, forming connected peristomes, with a short row of granules between the ends of the apertures and a continuous row at each angle of the segment. The latter winds itself between the zoœcial apertures so as to arrange them into longitudinal series, with seven or eight in the length of the segment.

Of all the species known to me *H. alternata* seems to be the nearest to this. The differences between them are however too obvious to require pointing out. *H. harrisi* occurs in the same beds, but its segments are longer and more slender, its zoœcia smaller, and the surface marking quite different.

Formation and locality.—The types are from the upper beds of the Cincinnati group, at Blanchester, Ohio, but the species has been noticed at other localities in Ohio, and at Richmond and Versailles in Indiana. I have also noticed similar segments in equivalent rocks at localities in Illinois, so that the species may be expected to occur in these beds at localities in southern Minnesota.

Helopora harrisi *James.*

PLATE III. FIGS. 11, *b*, *c*, and 12.

Helopora harrisi James, 1883. "The Paleontologist," p. 58.

Segments very small, acerate, about 3.5 mm. long, 0.22 mm. thick, hexagonal in cross-section; upper extremity slightly expanded, conical or pyramidal, with the angles prominent, the lower end striated, tapering, obtusely pointed or slightly bulbous; between the ends the sides are nearly parallel. Zoœcia in six longitudinal ranges, their apertures small, narrow-elliptical, often drawn out anteriorly, their margins thickened, about twice their length apart, with seven (usually) on each of the six faces. Peristomes connected lengthwise, their sides being co-incident or merged into the moderately developed ridges forming the angles of the segment. The later are nearly always straight. Interspaces between the ends of the zoœcial apertures occupied by a low rounded ridge, rising and spreading at each end into the peristomes. The best preserved examples exhibit a row of exceedingly minute papillæ on the peristomes and angle-ridges.

In transverse sections the zoœcia appear as six subequal wedge-shaped cells, arranged around the central axis. The outer investment is rather thin, but in most cases the projecting angles and the intermediate ridges are distinguishable. In vertical sections the anterior side of the zoœcia is nearly straight, forming an angle of about fifty degrees with the axis. The zoœcia are comparatively elongate, but the overlap is unusually little. Sections on the whole are much like those of *Nematopora lineata* Ulrich, as figured in Vol. viii, Ill. Geol. Sur., pl. XXIX, fig. 7, but the zoœcia are more elongate in *H. harrisi.*

I cannot doubt that this is the species named by Mr. James in the publication cited above, since the greater part of my specimens are from the same spot and layer that furnished his types. But for this certainly I would not be able to identify the species, Mr. James' description being very incomplete and incorrect in some of the points mentioned by him. I succeeded in obtaining free from the matrix fully one thousand segments, and as many of these as have been examined show clearly and uniformily six rows of cells, not two, three, or four as he supposed. He states also that the sides are constricted at the ends of the apertures, "giving them a chain-like appearance." This is most certainly not true of any specimen seen by me. His figures of the species too are as little or even less trustworthy. Indeed the two plates which accompany that number of "The Paleontologist" may be said to burlesque art illustration.*

*It is really a fair question whether a species so illy and insufficiently characterized as this, has any claim to recognition. In this case it happened that I had selected the same specific name for it, we having both intended to honor Mr. I. H. Harris, of Waynesville, Ohio, who sent each of us one of the original specimens.

The dismembered zoaria of this species literally made up a thin limestone layer, 5 to 35 mm. thick, and about 2 meters square, which occurred in the soft shales near Waynesville, Ohio. It is impossible to say how many segments may have belonged to a single zoarium, but judging from their exceeding abundance here it is more than probable that the number was often very large.

Formation and locality.—Rather a characteristic fossil of the upper beds of the Cincinnati group. The species is known from localities in Ohio, Indiana and Illinois, and has been found at Stony Mountain, Manitoba.

Mus. Reg. No. 8113.

HELOPORA (?) *sp. undet.*

PLATE III, FIG. 8.

Of this form my collection contains several segments that were found associated with *Helopora mucronata, H. quadrata* and *Arthroclema armatum.* After careful comparisons with those species, the last especially, I am obliged to regard them as probably belonging to an undescribed species, which, because of the paucity of the material at hand, I thought best to leave unnamed. A small one of what I believe to be the tertiary or last set of segments of *A. armatum* is illustrated, beside one of the supposed new species, on plate III by fig. 7. This is a little shorter than usual, agreeing in that respect very nearly with the form under consideration, but in the greater strength of its longitudinal ridges and in the character and number of the zoœcial apertures in a given space, it differs from the present species, while it agrees in these features with the ordinary form of the third set of segments of *A. armatum.* The segments in question are shorter than the average forms of either the secondary or tertiary segments of *A. armatum,* and taking into consideration the absence of a lateral socket, which should be present in segments of this diameter, if they belong to a species of *Arthroclema,* I think I am justified in maintaining, provisionally, that they belong to a species of *Helopora,* with characters, briefly, as follows:

Segments short, a little over 2 mm. in length, about 0.5 mm. in diameter, cylindrical, the upper extremity truncate, the lower tapering slightly but not pointed. Zoœcia in from eight to ten longitudinal rows, but the more obvious arrangement is in five transverse or subspiral rows. Apertures subovate, oblique, widely separated longitudinally, closely arranged transversely, the last fact, together with the prominence of the posterior border, giving the stems an annulated appearance. Delicate ridges, which do not cross over the elevated margins of the zoœcial apertures, define their longitudinal arrangement.

Compared with species of *Helopora*, only two, *H. spiniformis* and *H. mucronata*, require mention. Both have larger segments and the lower extremity more acute. In the first the ridges and superficial striations are also more conspicuous, while in the second the segments are curved and taper downward.

Formation and locality.—Galena shales, near Cannon Falls, Minnesota.

Genus ARTHROCLEMA, Billings.

Arthroclema, BILLINGS, 1862, Pal. Foss., vol. i, p. 54; ULRICH, 1886, Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 60; 1888, The American Geologist, vol. i, p. 232; 1890, Jour. Cin. Soc. Nat. Hist., vol. xii, p. 192, and Geol. Sur. Ill., vol. viii, p. 400.

Arthroclema (part), ULRICH, 1882. Jour. Cin. Soc. Nat. Hist., vol. v, p. 151.

Zoarium jointed, composed of numerous subcylindrical segments, celluliferous on all sides, arranged in a pinnate manner; articulation both terminal and lateral. Segments of three kinds, primary, secondary and tertiary. The first set forms the strong central stem, of which each part has normally one or two sockets on opposite sides for articulation with the smaller segments of the second set. The latter generally articulate in like manner, terminally with each other and laterally with the still more slender segments of the third set. Zoœcia subtubular, each occasionally with a diaphragm, their apertures ovate, oblique, the inferior border more or less prominent, arranged in rows between longitudinal ridges. Interspaces usually striated, often grano-striate.

Type: *A pulchellum* Billings.

Complete zoaria are known of only two species of this genus, the type and *A. billingsi.* This is unfortunate because of the difficulty of determining the range of variation that may obtain in the three sets of segments. If the student will examine fig. 7, on plate II, he may appreciate the difficulties referred to. This illustration represents the fine type specimen of *A. billingsi*, and gives a good idea of the arrangement and the differences in the size and length of the segments of the three sets that may occur in a species of *Arthroclema.* As shown in the figure the segments of the same set even may not be of uniform length. In *A. billingsi* the first of the secondary set is twice the length of those succeeding it. Then again it shows that while some of the secondary segments may articulate laterally with one of the tertiary set, many others may be without them. As all the zoarial parts spread approximately in the same plane, the development of tertiary segments must depend very largely upon the space available. In *A. billingsi* this was much less than in the other species since it is the only one known in which the primary segments articulate with four (two on each side) secondary joints. In all the other species there is only one on each side, so that their growth was less compact, and the chances for tertiary segments better. Still, it is possible that the third set of joints may not, in some species, have been developed at all. This seems to be true of *A. cornutum*, since lateral sockets have not been observed on any of the numerous secondary segments of that species seen.

Regarding the present work on the genus I regret that I have not been able to do the species justice in the way of illustration. I have sought to figure them as fully as the plates at my disposal admitted. But with so many conditions demanding representation, I was often at a loss in selecting the specimens which would go farthest in aiding the student to identify the species.

Respecting the distribution of the species, *A. cornutum* and *A. striatum* are known as yet only from the middle third of the Trenton shales of Minnesota. The next species is the *A. pulchellum* Billings, described from the Trenton limestones of Canada, and with which I am inclined to identify a number of segments found by me in the upper division of the shales at St. Paul and Cannon Falls. *A. billingsi* is from a similar (perhaps a little lower) horizon at Ottawa, Canada. The detached segments of *A. armatum* were abundant in washings of the Galena shales obtained from a locality near Cannon Falls. The last species is the *A. angulare*, described in vol. viii, Ill. Geol. Surv., from the upper beds at Wilmington, Ill. It occurs also at Stony Mountain in Manitoba.

The relations of *Arthroclema* to *Helopora* have already been discussed in the remarks on the latter genus.

ARTHROCLEMA STRIATUM, *n. sp.*

PLATE II, FIGS. 22 and 24, and PLATE III, FIGS. 28-33.

Under this name I propose to arrange a variety of segments that, though closely related to *A. pulchellum* Billings, are evidently distinct. The specimens consist (1) of a relatively small number of segments like the original of fig. 28; (2) hundreds like figs. 22 and 23, and (3) equally numerous more slender segments. They agree with each other in what I regard as specific characters, and in the following description are referred to respectively as primary, secondary and tertiary segments.

Primary segments 2.5 to 3.0 mm. long, from 0.7 to 1.0 mm. in diameter in the middle, spreading at the ends to a diameter of 1.2 mm. or more, the upper extremity flat, generally subcircular, the lower also abrupt but rising centrally into an obtusely conical elevation. Sometimes with only a single, large, deep and sharply defined socket, situated very near the base; more commonly with two, placed on opposite sides of the segment. Occasionally a third socket, this one small and illy defined, is placed near the upper end. Zoœcia in five or six longitudinal rows, with small oblique apertures, the posterior margin prominent; arranged in transverse rows, with six the usual number in the length of the segment; short segments (2.5 mm.) have five. Surface distinctly striated lengthwise, often thrown into strong, but never sharp, ridges between which the zoœcial apertures are arranged. The latter are always difficult to see. In drawing fig. 30 I overlooked them entirely, having mistaken certain depressions, which are often met with in these segments, for them. Since freeing the specimen from the matrix I find that it has really five rows of apertures, both longitudinally and transversely, of the same size as shown in fig. 33. With this correction the figure may still be of aid in the identification of the species, because it shows the striation of the surface better than the original of fig. 28. It should be added, however, that the latter shows the usual shape of the segments better.

Secondary segments five-sided, 2.7 to 3.2 mm. long, the length depending upon the number (six or seven) of transverse rows of zoœcial apertures, 0.35 to 0.5 mm. in diameter, the ends usually a little wider, the upper flat, the lower rounded. Zoœcial apertures in five longitudinal and six or seven transverse rows, small, oblique, drawn out above, their ends widely separated. Interspaces finely striated lengthwise, the angles sharp or rounded, formed by a raised central line and one or two similar lines on each side of it. An articulating scar or shallow socket has been observed just above one of the first cycle of zoœcial apertures, but their presence in the segments of this set is to be counted as an unusual occurrence. For this reason it is more than probable that most of the segments which are next described as tertiary are really young or terminal joints of the second order.

Tertiary segments about 3.0 mm. long, less than 0.35 mm. in diameter, very slender, four or five-sided, with sharp angles, the lower end rounded and tapering slightly, the upper sharply truncate. Zoœcia in four or five longitudinal rows, in six, but oftener in seven cycles, their apertures small, oblique, the raised margin highest posteriorly and running out on each side to the angle ridges. Behind each aperture usually a pair of very delicate striæ, the conditions being very much as in *Helopora spiniformis* (see plate III, fig. 4). Angles formed by a single raised line. These segments are distinguished from those of the second order by their greater tenuity, more oblique zoœcial apertures, and absence of striæ on the sides of the angle ridges.

As stated in the paragraph preceding the last, it is possible that many of the segments just described as of the tertiary set really represent the young stage of the secondary set. In that case it is probable that the four-sided joints only are tertiaries.

This species is readily distinguished from its associate, *A. cornutum*, by its longer and differently shaped segments, narrower zoœcial apertures and simply striated surface. It is closely allied to *A. pulchellum* Billings, but that species differs in having the segments a trifle shorter (eight or nine in 20 mm.), the articulating sockets situated near the middle instead of near the bottom of the joints, the primary segments less expanded at the ends, the zoœcial apertures more direct, larger and separated lengthwise by shorter interspaces.

Formation and locality.—The detached segments of this species are very plentiful on some of the thin plates of limestone found in the lower part of the Trenton shales at Minneapolis and St. Paul, Minnesota.

Mus. Reg. No. 8114.

Arthroclema cornutum *Ulrich.*

PLATE II, FIGS. 16-21 and 23.

Arthroclema cornutum ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 193.

Zoarium jointed, the segments five-sided, consisting possibly of three sets, but only two are positively known. For the sake of convenient reference these will be termed primary and secondary.

Primary segments five-sided,* about 2 mm. long, 0.5 to 0.7 mm. in diameter, with the five angles more or less well-defined, though never sharp, produced at the truncated and hollow upper extremity into as many horn-like projections. Near the lower extremity, which is often a little bulbous and radially striated, there is usually one rather shallow, subcircular articulating socket. It would appear that the sockets were placed in these alternately on opposite sides of succeeding segments. There may have been, as I believed, originally two sockets on some of the segments, but no more than one is to be seen on any of those that have since been freed from the matrix. Zoœcia in five longitudinal rows, and generally in four, rarely in five, cycles, the apertures of those in the uppermost cycle more oblique than the others and situated very near the upper extremity of the segment. Angles of segments, peristomes of oval zoœcial apertures, and the longitudinal interspaces more or less regularly papillose. With age the number of rows of papillæ at the angles increases from one to three or four.

Secondary segments also five-sided, 0.4 to 0.5 mm. in diameter, from 1.0 to 1.8 mm. long, the usual length about 1.2 mm., with five in about 6.2 mm. The length depends upon the number of cycles of zoœcial apertures. These are commonly only three, but four cycles are not infrequent. Lateral articulating sockets apparently wanting in this set. Otherwise very similar to the primary series. The papillose ornamentation of the surface however is generally more regular.

*In the original description I say "six-sided", but this proves to be an error.

Compared with other species *A. armatum*, of the Galena shales, has larger and much longer segments, six or seven rows of zoœcia, and the lower border of their apertures prominently produced. *A. striatum*, which is associated and more abundant on the same slabs, differs in having longer and differently shaped segments, smaller zoœcial apertures, generally six cycles of them, the surface striation finer and without papillæ, and in having the angles but little if at all produced at the upper extremity. *A. pulchellum* Billings, differs in a similar manner.

Formation and locality.—The detached segments of this species are rather plentiful on certain layers of the limestone plates in the lower part of the Trenton shales exposed in the railroad cut near the State University at Minneapolis.

Mus. Reg. No. 8115.

ARTHROCLEMA ARMATUM *Ulrich.*

PLATE II, FIGS. 8-11, 25 and 28-33, and PLATE III, FIG. 7.

Arthroclema armatum ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 194, fig. 19, a, b, c, and, d; not e, f, g, h.*

Zoarium jointed, consisting of three sets of segments, primary, secondary and tertiary, the first and second sets readily separable, the second and third probably indistinguishable in many cases.

Primary segments generally subcylindrical, often compressed and irregularly shaped, without regular longitudinal angles, the surface usually appearing as simply striated, with strong spines and zoœcial apertures indistinct; length unusually variable, depending upon the number of cycles of zoœcia in the segment, 3.0 mm. with seven cycles, 3.3 mm. with eight, 4.0 mm., the commonest size, with ten, and so on to 4.5 mm.; diameter varying with age from 0.5 to 1.0 mm.; ends truncate, the upper flat or raised centrally, the lower usually with a nipple-shaped prominence. Lateral articulating sockets deep, sharply defined, situated at or slightly above the middle of the length, so far as observed, never more than one to each segment; some are without any. Zoœcia in six ranges, their apertures oval, small, slightly oblique, easily overlooked, sometimes, especially in the vicinity of the articulating socket, closed, with seven in about 2.5 mm.; width of lateral interspaces varying with age. A strong tubercle just behind or near each aperture.

Secondary segments of about the same length as the primary set, usually about 3.6 mm. They are, however, more slender, none being more than 0.5 mm. in diameter, ranging from that down to 0.3 mm. Upper end terminating abruptly, spinous; lower end rounded. Lateral sockets faint, centrally situated, not often detected in this set. Zoœcia rarely in five, commonly in six, occasionally in seven longitudinal

*In the original work on this species one vertical section and three transverse sections of a Canadian example of *A. pulchellum* BILLINGS, were inadvertently given as *A. armatum*. These figures which are magnified x 25 instead of x 18, are reproduced in this volume on plate II.

rows, arranged between prominent ridges that become stronger with age. A transverse arrangement also prevails, with about seven in 2.5 mm.; according to its length from seven to twelve cycles, the usual numbers nine or ten, are to be counted in each segment. Apertures ovate, oblique, the inferior border very prominent, spine-like. With a favorable light, two exceedingly delicate striæ may be noticed in the longitudinal interspaces. These striæ are not only generally present in species of this genus, but also occur frequently in species of *Helopora*. They are not shown in figs. 10 and 11, having been overlooked.

As tertiary segments I propose to denominate a large number that seem to belong to this species but are more slender and differ in other respects from the ordinary forms of the secondary set. As a rule, they have tapering, subequal, rounded extremities, are shorter, 2.5 to 3.3 mm. long, 0.3 mm. or less in diameter, five or six-sided, the latter generally, with the angles obscure in the youngest, but becoming fairly prominent with age. At the same time the raised border of the zoœcial apertures, which at first is very thin, increases in strength and prominence. Six to eight cycles of zoœcial apertures in the length of a segment. Figure 7, on plate III, represents an average segment of this set. In still younger specimens the angle ridges are less conspicuous, while in going the other way an almost continuous chain of variation from it to fig. 10 on plate II, can be selected from the material before me.

This species is nearer *A. pulchellum* Billings, than I suspected at first. The only differences that I now would insist on are (1) the greater average length of the segments, those of the second order especially, of the present species; (2) the spine-like elevation of the inferior border of the zoœcial apertures, and (3) the less frequent branching of the zoarium. In the Canadian species, of which I have some very good material, the primary segments have almost invariably two lateral articulating sockets, while the majority of those of the second order have one at least. In *A. armatum*, however, the primaries have only one or none, and the secondaries are in most cases without any. The two species of the lower shales, *A. striatum* and *A. cornutum*, are readily enough distinguished. Both have the lateral articulating sockets situated lower on the segments; the former has, furthermore, smaller zoœcial apertures, more numerous and finer surface striations and only five instead of six ranges of zoœcia in the secondaries. The segments of *A. cornutum* are of a different shape and much shorter.

If complete zoaria of this species could be studied, it would not surprise me if they proved that the curved and tapering segments which I have named *Helopora mucronata*, and which are found in the same beds, are really parts of this *Arthroclema*.

Such a possibility may seem remote, yet its realization is rendered almost probable by the recent discovery of similarly curved and pointed segments that belonged unquestionably to the tertiary series of a small example of *A. pulchellum.*

Formation and locality.—Galena shales, near Cannon Falls, Minnesota, where it is associated with many other small Bryozoa. Also in the upper shales at St. Paul, Minnesota.

Mus. Reg. No. 8116.

Arthroclema, *sp. undet.* (1).

PLATE II, FIGS. 26 and 27.

This species is represented in my cabinet by five segments collected from the Trenton shales near Fountain, Minnesota. It may be distinct, but the material at hand is insufficient for the foundation of a species of this genus. Figures 26 and 27 (plate II) represent the two offering the greatest differences shown in the lot. One is incomplete, having lost the two upper cycles of zoœcia. It was evidently a younger segment than the other, being less coarsley marked, with the angle ridges straighter and more prominent. One of these segments shows a lateral scar situated near the center, but it is very faintly impressed and easily overlooked. The zoœcia form six rows, but one segment seems to have had only five, with rather large, oblique apertures; aside from the incomplete segment (fig. 26) the transverse arrangement of the apertures in the others is more or less irregularly spiral; five apertures, one at the extreme top, is the usual number in the segment length. Inter-apertural spaces rather irregularly grano-striate. Length of segments about 2.4 mm., diameter of same 0.35 to 0.4 mm.

The species to which these segments belong is probably a close ally of *A. pulchellum* Billings, on the one hand, and *A. striatum* on the other. These relations, however, cannot be determined satisfactorily until more complete collections are available.

Arthroclema, *sp. undet.* (2).

PLATE III, FIGS. 35-37.

Of this form, which is evidently related to the preceding and to A. *pulchellum* Billings, but, so far as I can see, not identical with either, I have over twenty-five more or less imperfect segments. These vary in length from 1.7 to 2.3 mm., and in diameter from 0.3 to 0.5 mm. In several a faint, centrally situated, lateral socket is distinguishable, and in most of them the zoœcial apertures, of which there are four or five cycles and six longitudinal rows, are inclined to be irregular in their arrangement. A number of specimens are preserved as casts of the interior, and in these (see plate III, figs. 36 and 37) a spiral arrangement of the zoœcia commonly prevails. The surface is striated, especially on the more regularly constructed segments, very much as in *A. pulchellum.* Though inclined to regard it as an illy nourished variety of that species, with shorter and more slender segments, I prefer, for the present, to leave the form unclassified specifically.

All the specimens of this form were collected by me in the upper part of the Trenton shales at St. Paul, Minnesota.

Genus NEMATOPORA, Ulrich.

Nematopora, ULRICH, 1888, The American Geologist, vol. i, p. 234; 1890, Illinois Geol. Surv., vol. viii, pp. 401 and 644.

Zoaria very slender, branching, continuous above the pointed basal extremity. Zoœcia subtubular, short, arranged in a radial manner around one or two exceedingly minute axial tubes. Apertures arranged in longitudinal series between smooth or granulose ridges, nearly direct, generally elongate-ovate and enclosed by a thin peristome. One or two diaphragms occasionally present.

Type: *N. ovalis* Ulrich (*N. quadrata* Ulrich, Ill. Geol. Surv., vol. viii, 1890).

Of this genus we now know about fourteen species. Seven of these are from Trenton rocks, one (undescribed) from the Cincinnati and Hudson River groups, five from the Anticosti, and one, *N. minuta* Hall, sp., from the Niagara of Indiana.

The genus differs conspicuously from the other generic types included in the *Arthrostylidæ* in having the zoarium continuous and dichotomously branched, the jointed character prevailing in the family being confined to the basal extremity. This part of the zoarium is, however, known of only one or two of the species, and it may yet be proven that in some of the species there is no basal articulation. But in the meantime, especially since the various forms agree very closely in zoœcial features, we may assume that the lower extremity was pointed and articulated with a small basal expansion. The relations to *Helopora*, Hall, are therefore very nearly the same as between *Escharopora*, Hall, and *Arthropora*, Ulrich.

NEMATOPORA OVALIS *Ulrich.*

PLATE III, FIGS. 24 and 25.

Nematopora ovalis ULRICH, March, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 197.
Nematopora quadrata ULRICH, Dec., 1890. Ill. Geo. Surv., vol. viii, p. 644.

Original description: "Zoarium ramose; branches birfurcating 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 zoœcia. Zoœcial 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 zoœcia. They also have the thin ridge that bounds each face more distinct from the elevated margins or peristomes of the zoœcial 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 zoœcial apertures; about five of the latter in 2.5 mm."

Careful comparisons between the New York types of *Nematopora quadrata* (*loc. cit.*) and the originals of *N. ovalis* have convinced me of their specific identity. My belief that the latter had larger zoœcia proved incorrect, and as many of them have also the double ridges at the angles of the branches, which were regarded as the main peculiarity of the former, nothing is left to distinguish them. It is to be admitted, however, that none of the New York examples of the species so far seen have more than four rows of zoœcia.

The large size of its zoœcial apertures will distinguish *N. ovalis* from the three species next described. *N. lineata* Billings, sp., of the Anticosti group, is a larger species with six or seven rows of zoœcia.

Formation and locality.—Galena shales, near Cannon Falls, Minnesota; Trenton limestone, Trenton Falls, New York, and Montreal, Canada.

Mus. Reg. No. 8110.

NEMATOPORA GRANOSA *Ulrich.*

PLATE III, FIGS. 17-20.

Nematopora granosa ULRICH, 1890. Jour. Cin. Soc. Nat. Hist, vol. xii, p. 196.

Original description: "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 zoœcia; those of the average size, pentagonal, and with five rows of cells. Zoœcial 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 of the ridges and interspaces, and the narrowness of the zoœcial apertures of this species distinguish it from all the others having the essential characters of *Nematopora* known to me. Under the microscope the general appearance of the zoarium is strikingly different from that of *N. ovalis*, with which it is associated. Equally marked differences will be noted when it is compared with *N. delicatula* and *N. conferta*, both of which likewise occur in the same beds. Externally, *N. granosa* presents not a little resemblance to small species of *Rhombo-*

ora like *R. lineinodis* Ulrich, and *R. regularis* (*Trematopora* and later *Orthopora regularis* Hall), but it is to be doubted that this resemblance is indicative of even remote relation. In *Rhombopora* the primitive cells are drawn out into long tubes which originate, just as they do in nearly all of the ramose *Trepostomata*, in various parts of the axial region. In *Nematopora*, on the other hand, the zooecia are comparatively short and arise along a definite axial line.

Formation and locality.—Galena shales, near Cannon Falls, Minnesota.

Mus. Reg. No. 8111.

Nematopora delicatula *Ulrich.*

PLATE III, FIGS. 26 and 27.

Nematopora delicatula Ulrich, 1890. Geol. Sur. Ill., vol. viii, p. 646.

Zoarium very small and exceedingly slender, ramose above the pointed basal extremity. Branches quadrangular, with the angles rather sharp, and the solid sides flat or gently convex, each from 0.15 to 0.18 mm. wide. Zoœcia rather long, in four ranges; apertures ovate or subcircular, about 0.12 mm. in length, separated by long, smooth intervals, each from 0.7 to 1.0 mm. in length; average length of zoœcia about 0.95 mm. Peristome thin, easily broken away; when perfect it forms a sharply elevated rim about each aperture.

The widely separated zoœcial apertures, and the exceeding delicacy and quadrangular form of the zoarium of this species distinguish it from all other species of the genus known. The associated *N. ovalis* often has only four ranges of zoœcia, but their apertures are so much larger that the two species cannot be confounded. The possibility of confusion with *N. granosa* and *N. conferta* is equally remote. Indeed, all of these four associated species are distinguished by sharply marked and easily recognized peculiarities.

Formation and locality.—Galena shales, near Cannon Falls, Minnesota. The original types of the species were collected from an equivalent horizon in Alexander county, Illinois.*

Nematopora conferta *Ulrich.*

PLATE III, FIGS. 21-23.

Nematopora conferta Ulrich, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 198.

Zoarium ramose, spreading nearly in a plane; branches dividing dichotomously at intervals varying from 1 to 3 mm., 0.4 to 0.5 mm. in diameter, subcircular in cross-section. Zoœcia in five or six longitudinal ranges, their apertures frequently arranged

*In the Ill. Geol. Surv. vol. viii, this horizon is given, in conformity with the preceding volumes of publications of that survey, as Cincinnati group, but at the top of p. 645 (*op. cit.*) it will be seen that I express a doubt as to their exact age, saying that "I am inclined to regard them as more likely representing an upper member of the Trenton group." I have now satisfied myself that they are equivalent to the Galena of the Northwest and the Trenton limestone of New York.

also in rows encircling the stems. Apertures rounded or broad-oval, slightly oblique, about 0.15 mm. in diameter, separated lengthwise by intervals a little greater than their diameters, with seven or eight in 2.5 mm.; peristomes thin, strongest and most elevated posteriorly. Interspaces striated, occasionally rising into strong ridges which separated the longitudinal ranges of zoœcial apertures for a short distance.

The smaller, subcircular apertures and differently marked interspaces, distinguish this species from *N. ovalis.* In *N. granosa* the zoœcial apertures are much narrower and alternately arranged, while the interspaces are papillose. *N. alternata* Ulrich, from a similar horizon in southern Illinois, has the zoœcial apertures arranged in quincunx, and differs in other obvious particulars.

Because of the rounded zoœcial apertures and their prevailing mode of arrangement, the branches of this species sometimes resemble those of *Protocrisina exigua* Ulrich, a cyclostomatous form that is associated with it at Cannon Falls. This resemblance may prove a little troublesome when the surface of the *Nematopora* is slightly abraded so that the striation of the interspaces is obscured. In all cases, however, when the specimens can be observed free from the matrix they may be distinguished at once by the fact that in the *Nematopora* the surface is celluliferous on all sides, while in the *Protocrisina* one side of the branches is striated longitudinally and *without* zoœcial apertures.

Formation and locality.—Galena shales, near Cannon Falls, Minnesota, where it is associated with the preceding species and many other small Bryozoa. *Prasopora insularis* Ulrich, is the commonest and most characteristic fossil of this horizon.

Family PHYLLOPORINIDÆ, Ulrich.

The genera comprised in this family, *Phylloporina, Drymotrypa* and *Chainodictyon,* are not very important in the way of specific and individual representation, but viewed from a biologic standpoint they are decidedly interesting. This interest attaches chiefly to the fact that they furnish excellent examples of what have been very aptly termed "comprehensive types."

A careful investigation of the internal structure of the various species of *Phylloporina* leads us to the conviction that at some time prior to the age of the Chazy there existed Bryozoa that combined characters which, during subsequent periods, became separately specialized and characteristic of widely different groups of families. Take, for instance, *P. trentonensis* Nicholson, sp., or *P. sublaxa, P. halli* and *P. corticosa* of the present work. In all of these remarkable forms we are reminded very strongly of typical *Trepostomata,* the subangular zoœcial tubes, their long "immature" region, diaphragms, mesopores and acanthopores being, all of them, characteristic of species of that suborder.

On the other hand, in *P. aspera* Hall, *P. reticulata* Hall, *P. dawsoni* Ulrich, and *P. asperato-striata* Hall, the zoœcial tubes are shorter and thus approach the ordinary cryptostomatous cell more nearly. Indeed, *P. dawsoni* can be, I think, shown to be the first recognizable stage in the line of development that later on resulted in the highly diversified *Fenestellidæ*. This same species, however, and the remark applies with equal force to *Drymotrypa dichotoma* Ulrich, has much to remind us of *Cyclostomata* like *Protocrisina*, the zoœcial orifice being but little constricted and the enclosing rim similarly prominent in all of them.

We can show, therefore, apparent relations to three suborders of Bryozoa, and it becomes a question of some difficulty to decide where the family had best be placed. The *Cryptostomata*, however, seem best adapted to receive them, chiefly for the reason that the *Phylloporinidæ* and *Fenestellidæ* are doubtlessly derived from the same stock, and the latter developed from the branch of the former mentioned.

Genus PHYLLOPORINA, *Ulrich.*

Retepora, as applied by various authors to Lower and Upper Silurian anastomosing Bryozoa (not Lamarck, 1801).
Gorgonia ?, HALL, 1847, (not Gorgonia Linnæus, 1745).
Intricaria, HALL, 1847; MILLER and DYER, 1878, (not Defrance, 1823).
Phyllopora (part.), ULRICH, 1882. Jour. Cin. Soc. Nat Hist., vol. v, p. 150.
Nov. gen. (undesc.), ULRICH, 1886. Contri. to Amer. Pal., vol. i, No. 1, p. 5.
Phylloporina, ULRICH, 1890. Geol. Surv. Ill., vol. viii, pp. 399 and 639.

Zoaria retiform, consisting of somewhat irregularly anastomosing, slender branches, with from two to eight ranges of zoœcia on the obverse side. Reverse convex, longitudinally striated, without apertures. Zoœcia tubular, often with the immature region very long, commonly with diaphragms. Apertures simple, unconstricted, rounded or subangular, generally with a peristome. Mesopores present, sometimes numerous, always closed at the surface; with diaphragms. Acanthopores often present.

Type: *P. trentonensis* (*Retepora trentonensis* Nicholson,* compare *Retepora fenestrata* Hall†).

This genus includes some of the earliest types of Bryozoa known. Beginning in the Chazy with three closely related species, the genus continues in the Birdseye and Trenton with six or seven well-marked forms, four of which are described in the following pages. In the Cincinnati group we have two species, in the Clinton one, and in the Niagara one. The genus is not known from later deposits.

The affinities and natural relations of the genus have already been touched upon in discussing the family. There remains to compare with *Retepora*, Imperato,

*Geological Mag., vol. 2, p. 37, 1875.
†Third Report N. Y. St. Mus. Nat. Hist., p. 178, 1850.

and *Phyllopora*, King, two genera that previous to 1888 were commonly employed in designating species of *Phylloporina*. The three genera agree in having similarly anastomosing zoaria, but the first belongs unquestionably to the *Chilostomata*, and is not known in rocks earlier than the Cretaceous. In the second the zoaria are short and constructed in every respect like those which characterize the *Fenestellidæ*. *Phyllopora* was not derived from the Lower Silurian *Phylloporina*, but from some type of *Polypora* subsequent to the extinction of the Silurian forms. Yet I am much inclined to believe that all three genera were derived successively from the same primal stock—not from each other—and that we have here merely a case illustrating the "tendency to variation in certain directions."

Compared with *Drymotrypa*, Ulrich, a genus beginning in the Trenton, and continuing to the Lower Helderberg, the present genus is distinguished chiefly, perhaps solely, by the anastomosis of the branches, these being dichotomously branched and free in *Drymotrypa*. In the Carboniferous genus *Chainodictyon*, Foerste, the zoœcia are somewhat shorter, and the back or "reverse" flatter and marked concentrically instead of longitudinally.

PHYLLOPORINA SUBLAXA *Ulrich.*

PLATE IV, FIGS. 1-7.

Phylloporina sublaxa ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 179.

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, varying considerably in shape and size, generally two or three times longer than wide; measuring, longitudinally, the average number in 1 cm. is between five and six; transversely, nine or ten in the same space. These measurements apply to the Tennessee specimens. In the Minnesota form of this species the fenestrules are smaller, averaging between six and seven in 1 cm. lengthwise.

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. Figure 2 on plate IV represents an enlargement of the reverse of a small fragment obtained from the lower part of the limestone at Minneapolis, Minnesota, by splitting 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, in which the reverse side was strongly striated.

Obverse face of branches strongly convex, carrying three to five rows of zoœcial apertures. These are subcircular, with a scarcely appreciable peristome, 0.09 mm. in diameter, and twenty-three to twenty-five in 5 mm. in each row, Interspaces depressed, generally forming distinct pits between the ends of the cells. Sometimes obscure raised lines may be detected between the rows of apertures. Acanthopores small, usually abundant, with no definite arrangement.

Thin sections show that the tubular primitive portion of the zoœcia, which is 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.

In some respects this species occupies an intermediate position between *P. trentonensis* Nicholson, sp., and *P. granistriata* Ulrich, both of which occur in higher beds of the Trenton, proper. The first is more robust, with stronger branches, more numerous rows of zoœcia, and the primitive portion of the zoœcia longer and straighter. The zoœcial apertures are also more angular. The second has more rigid branches, longer and narrower fenestrules, and the reverse side of the branches grano-striate and on the whole more delicately marked. The fenestrules of *P. reticulata* Hall, sp., are so much smaller that even very small fragments may be distinguished at once.

Formation and locality.—The Tennessee type specimens are from the Glade limestone at Lebanon and La Vergne. Fragments of probably the same species occur in the "Pierce limestone" at Murfreesboro. The Minnesota examples were obtained from the lower part of the limestone at Minneapolis.

Mus. Reg. No. 5954.

Phylloporina reticulata *Hall.*

PLATE IV, FIGS. 8–15.

Intricaria reticulata Hall, 1847. Pal. N. Y., vol. i, p. 17.
Phylloporina reticulata Ulrich, 1890. Ill. Geol. Surv., vol. viii, pl. LIII, figs. 2, 2*a*.

Specimens as seen, consisting of small, flat or undulating, reticulate expansions, being in each case evidently fragments of a depressed, funnel-shaped zoarium, probably not exceeding 5 cm. in diameter. Branches rounded in section, 0.2 to 0.3 mm. in diameter, inosculating at unusually frequent and regular intervals. Fenestrules somewhat elongate, about as wide as the branches, subrhomboidal in shape in the more regularly constructed fragments; their number in a given space is fairly constant, the extremes noticed in 1 cm. being ten and twelve. Reverse of branches convex, finely striated lengthwise.

Obverse strongly convex, with three rather irregular rows of zoœcia, their apertures subcircular, with a distinct peristome, about 0.1 mm. in diameter, eight or nine in 2 mm. Acanthopores abundant, irregularly distributed, rather large, especially so in the earliest forms of the species. Interspaces slightly concave, occasionally faintly pitted and striated.

In tangential sections the zoœcia are rather short, with a row on each side directed obliquely outward, and one series between them. The latter are wedge-shaped, and in deep sections appear as a more or less narrow central space. Diaphragms, one in each tube, have been observed.

None of the other Minnesota species of the genus are closely related. All of them are larger and stronger in both the branches and fenestrules. Nor are any of them found in the same beds with *P. reticulata*.

Formation and locality.—Both the geological and geographical distribution of this species is extended. It was described originally from the Trenton limestone of New York, and in that position occurs also at many localities in Canada and Vermont, and at one or two points near Cannon Falls in Minnesota. In this state, however, a form occurs in the lower and middle thirds of the Trenton (Birdseye) shales at Minneapolis and St. Paul, that is indistinguishable. As yet it has not been found in the upper third of the shales, but, as stated, it reappears in the Galena shales (typical Trenton) near Cannon Falls. It is not improbable that *P. clathrata* (*Intricaria clathrata* Miller and Dyer), of the Cincinnati group of Ohio and Kentucky, is not specifically distinct from *P. reticulata*. At any rate I have so far failed to detect sufficient points of difference.

Mus. Reg. No. 5955.

PHYLLOPORINA HALLI *Ulrich.*

PLATE IV, FIGS. 16-21.

Phylloporina halli ULRICH, 1890. Jour. Cin. Soc. Nat. Hist., vol. xii, p. 181.

Original description: "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 zoœcial apertures. These are about 0.09 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 1 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 zoœcial tubes are intersected by numerous diaphragms; that near their apertures they are still prismatic, resembling the zoœcia of a Monticuliporoid, and that a few small cells, perhaps acanthopores, are scattered among the true zoœcia.

"This is an easily recognized species, being also quite distinct 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 carinæ on both sides of the branches in that species serving amply in distinguishing them."

Formation and locality.—Rather rare in the upper third of the Trenton shales, at St. Paul, Minnesota.

PHYLLOPORINA CORTICOSA *Ulrich.*

PLATE V, FIGS. 1-10.

Phyllopora ? corticosa ULRICH, 1886. Fourteenth Ann. Rep. Geol. and Nat. Hist. Surv. of Minn., p. 61.

Zoarium reticulate, arising from an expanded base, at first funnel-shaped and poriferous on the outer side, later on becoming irregularly undulating. Poriferous side presenting the appearance of a *Fenestella* or *Semicoscinium* with strongly carinate and more or less flexuous anastomosing branches, and much depressed dissepiments. Width of branches varying from 0.35 mm. to 0.9 mm., but averaging about 0.5 or 0.6 mm.; thickness of branches and frond varying between 1.0 and 1.6 mm.

Obverse: On each side of the sharp, and, apparently, spiniferous median ridge, there are rarely one, usually two, rows of irregularly alternating, circular peristomate zoœcial apertures, with nine or ten in each in 2 mm. As a rule, the dissepiment-like connections between the branches are short, depressed, and may or may not carry a small number of zoœcial apertures distinct from the series belonging to the branches. Occasonally this division of the frond into rigid or flexuous branches and depressed dissepiment-like connections is not recognizable on all parts of the fronds. In such cases the branches anastomose rather irregularly and are simply convex, not carinate, the median ridge being absent. Fenestrules small, irregular, narrow, often indented by the projecting zoœcial apertures.

Reverse of branches very finely striated, tending, though less strongly than on the obverse face, to form median longitudinal ridges. Fenestrules varying in outline from elongate-elliptical to subcircular, their width rarely more, usually a little less than that of the branches, their length from one to three times the width; measuring transversely, six or seven in 5 mm.; longitudinally, the average number in the same space is three.

Tangential sections, cutting the frond parallel with the plane of its expansion and near the middle of its thickness, show that the branches are generally divided into approximate halves by an obscurely double vertical lamina, thicker than the walls of the zoœcial tubes diverging slowly from it toward each side. The tubes have thin walls, are long, and crossed by straight lines representing diaphragms. The number of the latter depends upon age. Where the section divides the tubes just beneath their apertures they are rounded or subangular, with slightly thickened walls, partially separated from each other by solidly filled interspaces or mesopores, that may be considerably smaller or even a little larger than the true zoœcia. Here and there, along the middle of the branches, a small acanthopore may be detected.

Vertical sections show that the zoœcial tubes arise also from a thick, laminated, basal layer, from which they diverge in an upward and outward direction. Their course toward the surface is very gradual in the lower half of the branch, but in the upper half the curve is slightly accelerated so that their apertures are nearly direct at the surface. Several diaphragms occur in the prostrate or primitive portion of each tube and in young examples (plate V, fig. 10) they may be absent in the more erect superficial portion. With age, however, additional diaphragms, now the diameter of a tube distant from each other, are introduced. Near the surface the tubes separate, leaving obconical interspaces, which are subsequently filled with solid or laminated tissue.

In transverse sections the branches are subrhomboidal, the lateral diameter being the shortest. The median ridge is shown to be an extension of the double vertical wall already mentioned. Between the two laminæ forming this wall, a series of very minute tubuli, similar to those found between the median laminæ of many bifoliate Bryozoa, may be observed. On each side of this mesial wall the zoœcial tubes are piled over each other, in one or two series, three or four high. These and other characters are well shown in fig. 9 on plate V.

This is a very remarkable species, and probably the most "comprehensive" type known to me among the Bryozoa. That its place is with *Phylloporina* will, I believe, be recognized at once, since it embraces every essential character of the genus. But it has others that are not possessed by any of the other species. Chief among these is the mesial ridge of the branches that brings to mind *Semicoscinium* and *Fenestralia* of the *Fenestellidæ*. As shown, this ridge is the superficial extension of a double median lamina constructed upon the same plan as in the *Rhinidictyonidæ*. Of course there is a difference in this that in the ordinary bifoliate Bryozoa the median lamina is horizontal while in the *P. corticosa* it is vertical to the plane of expansion. We find however precisely the latter condition in *Goniocladia*, Ethridge, jun., a Carboniferous genus with relations to the *Cystodictyonidæ*, and in *Reticulipora*, d'Orbigny, a Cretaceous genus of the *Cyclostomata*. If we add to these peculiarities the general resemblance of the zoœcial tubes of *Phylloporina* to those of ordinary *Trepostomata*, and the common possession of mesopores and acanthopores, we are confronted in *P. corticosa* by, to say the least, an unexpected mixture of characters. These facts are not mentioned because they are believed to indicate true relationships among the diverse types enumerated. On the contrary, it is more than doubtful that any two of them belong to the same line of development. Still, there is more than mere coincidence in the combination of characters seen in *P. corticosa*, and in the genealogical studies that will be in order sooner or later, they should be borne in mind.

Formation and locality.—Upper third of the Trenton shales, near Oxford Mills, Goodhue county, Minnesota, where it is abundant. A few specimens have been found also at St. Paul, in equivalent beds.

Mus. Reg. No. 3495.

Suborder TREPOSTOMATA, Ulrich.

In nearly every respect this suborder is to be considered pre-eminent among the Bryozoa of the Lower Silurian rocks; and this is as true of those in the lower horizons of the system as developed in Minnesota, as it is of those that have been so long known in the Cincinnati rocks. As was stated in the introduction, the lower beds holding Bryozoa in Minnesota are really very near the apparent inception of the class, the oldest forms known being from the Chazy. This fact should not be forgotten when the characters of the species and genera seem unstable and troublesome to classify. That is to be expected, because, near their point of origin all classes of animals sufficiently studied may be shown to have been unsteady in their development, new features having been introduced or dropped with surprising rapidity and frequency. Some of these, at first wavering characters, later on, when the class became fully established, assumed fundamental importance.

In the Minnesota shales, the minor or generic types of structure especially were as yet most unstable, and the mixture that resulted in consequence is sometimes so great and perplexing that it is perhaps impossible to do full justice to the affinities of many species by any known practical method of classification.

The nearest approach probably to this desirable end is to be attained by the strictly genealogical system of classification, which I may confess I am more than inclined to adopt fully. The intricacy of this comparatively new and little understood system seems to be the chief bar to its early and complete acceptance by naturalists. And yet, so far as my experience goes, there is nothing very simple in the ramifications of organic differentiation. On the contrary, forms are so intertwined in their relations that to unravel them is a matter of the utmost difficulty and patient inquiry. One of the more common of these difficulties is when we find a number of forms agreeing apparently closely in all characters assumed to be generic, and of which we have traced out the derivation of each so that we know them to have originated in different stocks or lines of development. Among many cases of this kind, that of *Homotrypella ? ovata* may serve as an example. This species has all the *essential* characters of *Homotrypella*, and yet I believe I can show conclusively that it represents a departure from a line that originated in *Homotrypa* and later on, indeed soon, developed into the *Eridotrypa mutabilis* Ulrich, group of species.

We know other species as well that stand in similarly equivocal relationship to *Homotrypa*. A careful study of these brings us to two conclusions: (1) *Homotrypa* generally manifested an inherent tendency to variation in that direction (*i. e.* to develop mesopores), and (2) that such forms as *Homotrypa similis* Foord, are to be regarded as *reversions* from the line of *Homotrypa-Eridotrypa*. Some of the questions involved would be more easily answered were it not for the almost contemporaneous existence of the variously differentiating types.*

*My studies have served in a number of instances to throw light upon several as yet little developed thoughts in evolution. Chief among these is the one occasionally referred to by me as a "Tendency to variation in certain directions." This expression may sound simple enough, but the conditions expressed, providing they have been read aright, are really of great importance in the classification of animal nature. Of course I cannot here enter into a full discussion of the theory, but a few ideas and facts bearing upon it seem desirable.

As results of presumed "tendencies" we find conditions that may be expressed as follows: After a species has once thrown off varieties of certain kinds, and these have died out, you may expect similar variations from continued decendants of the type or species. Cases: (1) *Dekayella prænuntia* and varieties, and corresponding *D. ulrichi* and varieties (see remarks under description of *Dekayella*); (2) the lower and middle Trenton species of *Callopora, ampla, pulchella, persimilis* and *dumalis*, described on succeeding pages, corresponding respectively to species *subplana*, *dalei* and *ramosa*, and an undescribed species, of the Cincinnati rocks; (3) the Lower Helderberg and Devonian species now classed as *Thamniscus*, though derived, like the more typical Carboniferous and Permian species of that genus, from *Polypora*, are not the *direct* ancestors of the latter, the first set of species having died out before the second were evolved; (4) *Fenestella* exhibited a continual tendency to throw off varieties and species that gradually assumed the characteristics of *Polypora*. Many other cases might be cited, but if those mentioned are followed up by the student I have no doubt he will find enough to convince himself that tendencies in variation or evolution were preserved dormant under retrogression, but manifested quickly enough when the proper conditions were presented. May not this idea explain the peculiar reapparition of cyclostomatous types discussed on pp. 121 and 122?

Two other thoughts have suggested themselves in this connection. The first is that varieties and species were in some instances reabsorbed into the parent stem. The other relates to an *approximation in structure* (1) by contemporaneous forms or species that have had a common origin (*e. g. Callopora undulata, C. incontroversa, C. angularis* and *C. ampla*, all varying toward *C. multitabulata*), and (2) by forms known to have been derived through different lines of development gradually assuming similar characters, as in the case of *Homotrypa minnesotensis-Homotrypella ? ovata* above described.

On plate XIX the figures up to No. 19 give an idea of the beginning of the line of development referred to in the latter part of the paragraph preceding the last. In *Homotrypa minnesotensis* we have what must still be regarded as a true species of the genus.* Even here, as shown in fig. 3, a tendency to interpolate mesopore-like interspaces is occasionally manifest. In *H. exilis* this tendency is more strikingly expressed and permanent, (see figs 13–16), while in *H. separata* it has progressed to such an extent that the zoœcia are rounded in shape instead of angular. These three forms all occur in the lower third of the Trenton shales. In the middle third we find a fourth stage in the development toward the Galena shales species provisionally called *Homotrypella ovata.* This fourth stage has been named *Homotrypa* (?) *intercalaris* and, as may be seen from the cut on a succeeding page, its characters are very nearly intermediate between those of the species *separata* and *ovata.*

Difficulties like these were encountered all through my work on the Minnesota Bryozoa, and now as it nears completion I realize, probably better than any one else can, that the result, despite my utmost efforts, is not final nor even entirely satisfactory in some parts. Had I followed my inclination and adopted a genealogical arrangement throughout it might have been better, because I believe it would have proven more permanent. But the criticism sometimes made that individual peculiarities are magnified into specific, and specific into generic, seemed to indicate a state of knowledge not sufficiently advanced for the proper appreciation of all the innovations that it would have been necessary to enter into. Perhaps I ought not to have noticed criticisms which, like these, originate in ignorance of the fact that characters preserved in hundreds of specimens are not to be viewed as "individual." But I have done so, and now must hope that the use of the interrogation point in cases of the kind discussed may be deemed sufficient for immediate needs.

To prohibit repetition as much as possible I shall, in the course of the following pages, frequently refer the student to the preceding paragraphs.

Family MONTICULIPORIDÆ, Nicholson, emend. Ulrich.

This family is strongly represented in the Lower Silurian rocks of Minnesota, there being here one or more species of every genus included in the family except *Peronopora,* Nicholson. The individuals of the species too are generally abundant, especially those of *Prasopora* and *Homotrypa,* so that they constitute no inconsiderable part of the collections from the various horizons.

**H, subramosa,* illustrated on the same plate, is more nearly like the prevailing Hudson River group types of the genus.

The principal and almost infalliable distinguishing peculiarity of the family is the cystiphragm. As a rule these structures form continuous series in the zoœcial tubes, and in all such cases their nature is at once determinable in either vertical or tangential thin sections. But in the genera *Monticulipora* and *Mesotrypa* they are often modified so that they might be mistaken for simple, oblique or slightly curved diaphragms. On plate XV figures 8 and 9 illustrate the latter, while of the usual form of the cystiphragms many examples are figured on plates XV to XIX.

Genus MONTICULIPORA, d'Orbigny.

Monticulipora, d'ORBIGNY, 1850. Prodr. de Paleont., t. i, p. 25.
Monticulipora (part.), NICHOLSON, 1879. Struct. and Affin. of the Pal. Tabulate Corals, p. 269.
Peronopora (part.), NICHOLSON, 1881. "The Genus Monticulipora," p. 215.
Monticulipora, ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, pp. 153 and 232; 1890, Geol. Surv. Ill., vol. viii, pp. 370 and 407.

Zoarium massive, lobate, subramose, laminar, incrusting, or frondescent. Surface usually tuberculated, sometimes even. Monticules closely arranged, usually conical, often elongated or compressed. Zoœcia polygonal, generally rather small, with thin and, internally, peculiarly granulose walls. Mesopores few, generally absent entirely. Cystiphragms present in the zoœcial tubes, both in the axial and peripheral regions of the zoarium, usually in continuous series, but often isolated. Acanthopores small, more or less numerous.

Type: *M. mammulata* d'Orbigny.

As now restricted this genus embraces but a small part of the incongruous material for which the genus was a receptacle from the day it was established. Still, no less than eighteen species having the essential characters of *M. mammulata*, all of them Lower Silurian save one, are known to me. The earliest of these is from the Birdseye limestone, and several belong to the Trenton proper; but it is in the Hudson River rocks that the genus has its strongest development. So far the genus is not known in Upper Silurian deposits, and it is possible that all its species became extinct at the close of the Lower Silurian. If that should prove to be true the *M. winchelli* Ulrich, described from the Hamilton of Michigan, could not be retained as a true member of the genus, since its line of development would necessarily be different.

Monticulipora wetherbyi *Ulrich.*

PLATE XV, FIGS. 7 and 8.

Monticulipora wetherbyi Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 239, pl. X, figs. 4-4*b*; 1889, Contri. to the Micro-Paleon. of the Cambro-Silurian Rocks of Canada, pt. ii, p. 30.

Zoarium attached to foreign objects, forming thin crusts or small depressed-conical masses. Surface gently monticulose, sometimes nearly even. Zoœcia polygonal, with very thin walls, the diameter of those of the ordinary size about 0.25 mm. Clusters of larger cells attaining a diameter of from 0.3 to 0.38 mm. occupy the summits and slopes of the monticules, or in the smooth forms are scattered over the surface at intervals of about 2.5 mm., measuring from center to center. A few small cells (? mesopores) may be detected, especially at the center of the monticules, but they are always an inconspicuous feature and being of various sizes are probably to be regarded as merely young zoœcia. Acanthopores rather large and numerous in the original Kentucky types of the species, small and few in the northwestern form.

In longitudinal sections the zoœcial tubes have thin walls with the granulose structure characteristic of the genus. The transverse partitions, occurring at intervals of a tube-diameter or more in the lower half of the tubes and little more than a third of that distance apart near the surface, seem really to be all of the nature of cystiphragms, though frequently appearing in the sections as straight diaphragms. In transverse sections the tubes are angular and thin-walled, with strong acanthopores—one at most of the angles—in the Kentucky specimens, and much smaller and fewer ones in the Minnesota and Manitoba form of the species. The cystoid nature of the diaphragms is generally recognizable in these sections, but the cresentic line, which is the unfailing mark of these structures, may not be detected except in only a few of the zoœcia.

Formation and locality.—Rare in the Birdseye limestone of central Kentucky. A single example was found in the lower limestone at Minneapolis. The species also occurs at St. Andrews, Manitoba.

Mus. Reg. No. 5967.

Monticulipora incompta, *n. sp.*

PLATE XV, FIGS, 9-12.

Zoarium parasitic, forming inconsiderable crusts or small masses upon shells, 1 or 2 cm. in diameter and several mm. thick. Surface even, with inconspicuous clusters of cells of slightly larger size than the average. Zoœcia polygonal, with thin walls (comparatively thick for the genus), the ordinary size varying between 0.2 and 0.25 mm, in diameter, while those in the clusters mentioned do not exceed 0.32 mm.; about eight in 2 mm. True mesopores wanting, the small cells being shown by thin sections to be merely young zoœcia. Acanthopores small, inconspicuous externally.

The internal structure is so well illustrated on plate XV that a detailed description is rendered superfluous. The chief peculiarity of the species is the minutely cellulose and roughish character of the zoœcial walls. In all other respects the species agrees closely enough with *M. wetherbyi* and *M. lamellosa* Ulrich, the latter from the Hudson River rocks of Illinois.

Formation and locality.—Rather rare in the middle third of the Trenton shales, at Minneapolis, Minnesota.

Mus. Reg. No. 5968.

Monticulipora grandis *Ulrich.*

PLATE XV, FIGS. 1-6.

Monticulipora grandis Ulrich, 1886. Fourteenth Ann. Rep. Geol. and Nat. Hist. Surv. Minn., p. 78.

Zoarium irregularly massive, often tending to become lobate or subramose. Zoœcia polygonal, with thin walls. Surface without monticules, but exhibiting at intervals of about 5 mm. conspicuous groups of cells larger than the average; of the latter nine or ten occur in 3 mm, while some of those in the clusters have been observed to reach a diameter of 0.5 mm. No mesopores. Acanthopores very small, few, practically wanting. When perfectly preserved (see plate XV, fig. 4) the cystiphragms are often to be seen in the mouths of the zoœcia, giving them the false appearance of being very small and situated at the bottom of a wide sloping area.

Internal structure: In the vertical sections the zoœcial tubes proceed to the surface in straight or curved lines, according to the form of the zoarium. They are provided with thin walls and usually two more or less closely arranged series of cystiphragms, one on each side of the tube, the narrow intervening space being crossed by an approximately equal number of straight diaphragms. The variation and relative disposition of parts is shown in fig. 6 of the plate cited. The lower half of the figure is taken from the lower part of the section where the transverse partitions are less closely arranged than near the surface of the zoarium. The walls have a lineo-granose structure. Tangential sections show that the zoœcial tubes are polygonal and thin-walled, the opening left by the cystiphragms ovate or subcircular and situated laterally or subcentrally. At the angles of junction the walls are slightly thickened, and there is some evidence to show that very small acanthopores were developed at these points.

This fine species has an external resemblance to irregular examples of *M. lævis* Ulrich, from the Cincinnati group of Ohio, but the zoœcia and internal structure of *M. grandis* are so much larger and different that the relation between the two species must really be quite remote. Excepting that mesopores are wanting entirely, the interior, as brought out by thin sections, is very similar to *Prasopora contigua* Ulrich, and I have considered the advisability of referring the species to *Prasopora* rather than *Monticulipora*. For the present, however, we must conclude that the absence of mesopores and lobate-massive instead of discoid growth are features sufficient to disbar the species from *Prasopora*.

Formation and locality.—At the base of the Trenton shales and the top of the underlying limestone at Minneapolis and Cannon Falls, Minnesota. Vertical range apparently very limited.

Mus. Reg. No. 5969.

MONTICULIPORA ARBOREA, *n. sp.*

PLATE XX, FIGS. 1-9 and 13, 14.

Zoarium dendroid, rising to a hight of 4 or 5 cm.; branches subcylindrical; dividing at intervals varing between 5 and 20 mm.; surface with low monticules, or smooth. Zoœcial apertures small, subangular, enclosed by rather thick, minutely granulose walls, on which small acanthopores, one or two to each zoœcium, are to be distinguished from the numerous small granules, which, together with the acanthopores, are quickly removed when exposed to the weather. About fourteen of the cells between those occupying the monticules or those in the clusters occur in 3 mm. Mesopores wanting.

Internal characters: The tabulation of the zoœcial tubes is compact throughout, and very much so in the peripheral region. The tubes bend outward in a gradual curve from the imaginary axis, and have cystiphragms from the beginning. In the axial region these are large and about two-thirds of the tube-diameter apart, becoming gradually a little nearer to each other until the fully matured condition of the species is reached, when they recur at intervals scarcely equalling one-fourth of the diameter of the tube. They also change their shape here, the opening which had been lateral (see transverse section, pl. XX, fig. 3) is now narrower and produced so that it extends nearly across the center of the zoœcial cavity. This is shown best in tangential sections, parts of two of which are represented in figs. 4 and 6 on plate XX. Figure 4 shows the structure immediately beneath the surface, with small acanthopores and numerous smaller pores in the walls and cystiphragms. In figure 6, showing the appearance at a slightly lower level, the walls are thinner and the acanthopores apparently wanting. Figs. 13 and 14 (plate XX) represent tangential and vertical sections of a Kentucky specimen of this species in which we note an unusual condition, namely, in some parts of the axial region there is a total absence of both diaphragms and cystiphragms. In other parts of the same section, however, these structures are developed in the usual manner, so that it is allowable to assume that their occasional absence is merely an abnormal condition. The tangential section represents a condition very nearly intermediate between figs. 4 and 6 of the same plate.

In many respects this species resembles *Atactoporella ramosa*, occurring in the bed of shales next beneath, but the surface of the latter is more abundantly spinulose. Thin sections, especially tangential, are easily distinguished. The true position of the species seems to be nearer the frondescent variety of *M. mammulata* d'Orbigny, described by Nicholson from the Cincinnati rocks under the name of *M. molesta*.

Formation and locality.—Galena shales at several points near Cannon Falls, Minnesota, and at Decorah, Iowa. In Kentucky the species occurs in the Trenton shales between Burgin and Danville, and at Frankfort.

Mus. Reg. Nos. 7631, 8035. 8048, 8062.

Monticulipora (?) cannonensis, *n. sp.*

PLATE XX, FIGS. 10-12.

Zoarium ramose, branches subcylindrical, 6 to 9 mm. in diameter, surface even, without monticules, but exhibiting the usual clusters of large cells. These, however, are inconspicuous in this species. Zoœcia angular, with thin walls, about twelve in 3 mm. Mesopores and acanthopores apparently wanting, the occasional small cells wedged between the ordinary zoœcia being merely young or abortive.

Internal characters: All that is known of these is shown in figures 10 to 12 on plate XX. The characteristic features are (1) the greatly crowded diaphragms and cystiphragms, (2) the presence of the latter throughout the length of the tubes, (3) the unusual tenuity of the walls in tangential sections, and (4) the almost total absence and exceedingly small size of the acanthopores.

The generic position of this species is somewhat in doubt. The ramose habit of growth, and all the other characters save one, are indicative of *Homotrypa*. This character is the development and continuous presence of cystiphragms in the axial region of the zoarium. In this respect the species agrees with *M. arborea* and *M. grandis,* and differs from all species of *Homotrypa* in which these structures should be developed in the peripheral region only. Even granting the importance of this distinction it should be understood that the present arrangement of the species is regarded as provisional.

Compared with *M. arborea,* the species under consideration is distinguished by having larger zoœcia and thinner walls. The internal differences will be appreciated at once in comparing the various figures of the two species given on plate XX. *Homotrypa callosa,* illustrated on the same plate, has thicker walls, fewer diaphragms and no cystiphragms in the axial region.

Formation and locality.—Rare in the Galena shales, near Cannon Falls, Minnesota.

Genus ATACTOPORELLA, Ulrich.

Atactopora (part.), ULRICH, 1879. Jour. Cin. Soc. Nat. Hist., vol. ii, p. 119.
Atactoporella, ULRICH, 1883, Jour. Cin. Soc. Nat. Hist., vol. vi, p. 247; 1890, Geol. Surv. Ill., vol. viii, p. 370.
Peronopora (part.), NICHOLSON, 1881. "The Genus Monticulipora," p. 215.

Zoarium generally forming thin crusts over foreign bodies, rarely lobate or subramose. Surface commonly with monticules. Zoœcia with very thin inflected walls, their apertures irregularly petaloid; internally with cystiphragms. Mesopores angular, numerous, often completely isolating the zoœcia; at first open and distinctly tabulated, but, when fully matured, largely or entirely filled by a deposit of sclerenchyma. Acanthopores very numerous, varying in size with the species, encroaching more or less upon the zoœcial cavity.

Type: *Atactoporella typicalis* Ulrich.

The affinities of this genus are with *Monticulipora* on the one side and *Peronopora* on the other. From the first it is distinguished by the abundant development of mesopores and the more numerous acanthopores. These are not only usually smaller in *Monticulipora,* but they also do not inflect the zoœcial walls. In *Peronopora,* as restricted by me, the zoarium is bifoliate, and the mesopores are not filled up with age in the manner characteristic of *Atactoporella.*

There may be in all about twelve species of this genus known to me, six of which are described from the Cincinnati rocks in the papers cited above. The same series of beds afford at least two new forms, and the Trenton of Kentucky and Tennessee two more, while the Birdseye and Trenton of Minnesota add the following species to the list.

Atactoporella typicalis, var præcipta, *n. var.*

PLATE XV, FIGS. 16 and 17; PLATE XVIII. FIGS, 1-4.

This form, though much earlier, is too much like the Cincinnati *A. typicalis* Ulrich (Jour. Cin. Soc. Nat. Hist., vol. vi, p. 248, 1883), to be distinguished specifically. The resemblance is so close that the original description may, with a few trifling alterations, be made to fit the Minnesota form. Hundreds of feet of strata, however, intervene between the two horizons respectively held by the two varieties, in which the species is unknown. It would seem, therefore, to be a case of reapparition, not necessarily of the same species, but of the same type of structure, similar to the cases of *Callopora* and *Dekayella* noticed in this work.

The characters of var *præcipta* are as follows:

Zoarium forming small thin crusts, rarely exceeding 1 mm. in thickness, over ramose Bryozoa and shells. Surface minutely spinulose, without monticules, except in rare instances (see plate XVIII, fig. 4), but exhibiting at intervals of about 2.5 mm., measuring from center to center, clusters of cells slightly larger than the average between which the interspaces are also a little thicker than usual. Zoœcial apertures floriform, the walls thin and at each inflection raised into a small spine, the surface extension of an acanthopore, arranged in moderately regular, diagonally intersecting series, averaging fourteen in 3 mm. Interspaces narrowing with age, very thin, with the zoœcial walls largely in contact, the apertures direct and the mesopores small and easily overlooked in fully matured examples; thicker, with the mesopores more distinct and the zoœcial apertures drawn out obliquely in younger stages of growth. Acanthopores numerous, small but sharply elevated, situated in the zoœcial walls, four to seven, usually five or six, around each aperture.

Internal characters: In tangential sections the zoœcial walls are very thin and indented more or less sharply at from four to seven points in their circumference These inflections of the wall are emphasized by the acanthopores, one of which occurs at each point and appearing in nearly all cases to be formed on the inner side of the wall. A few of the zoœcia may be completely isolated by the intervention of irregularly-shaped mesopores, but as a rule they are in contact at limited points. The mesopores never form more than a single row, and their walls are entirely without acanthopores. The crescentic cut edges of the cystiphragms, sometimes two or even three in each, are to be seen in each zoœcium. On account of the nearly equal thickness of these edges and of the walls of the zoœcia and mesopores, it is often difficult to discriminate between the various lines shown in tangential sections. Good vertical sections are difficult to prepare, because of the tenuity of the zoarium. On plate XV, fig. 16 illustrates the characters as brought out in a section taken from a young example. The section drawn on plate XVIII, fig. 2, was prepared from the thickest specimen seen. Between these two figures the student will be able to work out the essential features without further comment. It might be well, however, to direct attention in the last figure to the infilling and contraction of the mesopores in the upper half. Also to the fact that some of the zoœcial tubes in vertical sections, and the same remark applies to all Bryozoa having cystiphragms, may *appear* to be, in part at least, crossed by complete diaphragms. This appearance however, is merely the result of the different directions in which the cystiphragms cross the various tubes shown in the section. To obtain the characteristically curved line of the cystiphragm it is necessary that the section pass nearly *across* them. When the section passes through the tube parallel with the inner edges of the cystiphragms they must necessarily appear as straight or oblique lines, thus simulating true diaphragms.

This variety differs from the typical form of the species in the following particulars: The zoœcia are a little larger, the mesopores less numerous and often of larger size, the acanthopores one or two more to each zoœcium, and the tabulation a little more compact. Compared with other species, *A. typicalis* is readily distinguished by the exceeding tenuity of the zoœcial walls, and the greater projection inward of the acanthopores. The latter are more numerous than in any of the other Minnesota species known.

Formation and locality.—The types of *A. typicalis* are from the Utica horizon of the Cincinnati section at Cincinnati, Ohio, and vicinity. The present variety *præcipta* is from the middle third of the Trenton shales at Minneapolis, St. Paul, Fountain, and other localities in Minnesota.

Mus. Reg. Nos. 5983, 5984.

ATACTOPORELLA INSUETA, *n. sp.*

PLATE XV, FIGS. 13-15; PLATE XVIII, FIGS 5-8.

Zoarium forming thin crusts over shells, crinoid columns, and ramose Bryozoa, generally about 1 mm. in thickness. Surface with clusters of large cells at intervals of 3.3 mm., usually little or not at all elevated, at other times rising into low and broad monticules. Zoœcial apertures in old stages subangular and with thin interspaces in which the mesopores are not readily distinguishable; in younger stages more rounded, often ovate, with the interspaces usually somewhat wider and the mesopores obvious; walls thin, but little inflected. In the commonest form of the species there are from thirteen to fifteen zoœcial apertures in 3 mm., but in the variety illustrated in figs. 7 and 8 on plate XVIII, only eleven are to be counted in the same space. Acanthopores of medium size, two to four to each zoœcium, situated in the angles of junction and between the angles in the walls of both the zoœcia and mesopores. In most cases the acanthopores are not very conspicuous at the surface. This is in part due to attrition, since on protected spots they are distinct enough, giving the surface a minutely granulose character of somewhat coarser and looser pattern than in *A. typicalis.* In a variety represented by a dozen or more specimens these structures are much more strongly developed. Indeed, these specimens remind one very much of *A. schucherti* Ulrich, so far known only from the upper beds of the Cincinnati group in Ohio.

Internal characters: These are so well illustrated on the two plates above cited that detailed descriptions are rendered unnecessary. It will suffice to say that the mesopores, though usually rather large, are variable in size and distribution, that the zoœcia in the spaces between the aggregations of large cells are often in contact with each other for more than half their circumference, that the walls are a little thicker than in *A. typicalis,* the acanthopores less numerous, larger, and yet not projecting inward so much, while the tabulation of both sets of tubes is much less compact.

As has been intimated, two varieties might be distinguised from the typical and more common form of the species. The first differs in having larger zoœcia, the second in having much stronger acanthopores, these being larger and prominent enough at the surface to obscure the view of the zoœcial apertures. The latter may be compared with *A. crassa,* the following species, but they are too distinct in vertical sections to be confused.

Formation and locality.—Middle third of the Trenton shales at Minneapolis, St. Paul, Fountain, and other localities in Minnesota where that horizon is exposed.

Mus. Reg. No. 5985.

Atactoporella crassa, *n. sp.*

PLATE XV, FIGS. 18-21.

Zoarium a small, irregularly hemispheric mass, growing upon some foreign object, 2 or 3 cm. in diameter and 5 to 10 mm. in hight. Surface without monticules, nor have distinguishable clusters of either large or small cells been detected. Zoœcial apertures subangular, rounded or irregularly outlined, inclosed by thick walls, prominently elevated at most of the angles of junction into strong acanthopore spines; about fourteen apertures in 3 mm. Mesopores less numerous than usual, small and difficult to detect at the surface.

Internal characters: Considerable variety of structure, depending upon age, is exhibited in different tangential sections or in parts of the same section. These, as is shown in figures 18 to 20 (pl. XV), consist of a gradual thickening of the zoœcial walls, and strengthening of the acanthopores, causing the mesopores, which in the thin-walled regions are large and distinct enough, though never as numerous as in most other species of the genus, to be more or less completely obliterated. Cystiphragms occur in every zoœcial tube. The opening in them varies from subcircular to semiovate, according as they are situated subcentrally or at one side of the zoœcium. Vertical sections (pl. XV, fig. 21) show that the cystiphragms and diaphragms in both sets of tubes are equally crowded. It is, therefore, difficult to distinguish the mesopores from those zoœcial tubes in which the curved section of the cystiphragms is not shown.

This is a well marked species and readily separated from *A. schucherti* Ulrich, and certain varieties of *A. insueta*, which it resembles chiefly in the large size of the acanthopores, by the much greater abundance of transverse partitions in the tubes. The zoarium is also heavier, and the zoœcial walls thicker. A nearer relative apparently than either of the species compared is found in an undescribed species occurring near the tops of the hills at Cincinnati, Ohio.

Among associated species that might be confounded there are two of *Leptotrypa*, one, a parasitic undescribed form, the other, subglobular, described in this volume as *L. acervulosa*. Both are distinguished externally by having much thinner walls and inconspicuous acanthopores. When sectioned the *Leptotrypas* will of course be separated at once by the total absence of cystiphragms.

Formation and locality.—Galena shales, St. Paul and near Cannon Falls, Minnesota.

ATACTOPORELLA RAMOSA, *n. sp.*

PLATE XX, FIGS. 22-27.

Zoarium erect, subramose, branches compressed, dividing once or twice, 3 to 6 mm. thick, 5 to 10 mm. wide. Surface minutely spinulose, and elevated at intervals of about 2 mm. into small monticules, varying in different examples from low and rounded to prominently conical in shape. Slopes of monticules occupied by cells of slightly larger size than the average; their summits, however, often appear solid, these being, in most cases, formed by small aggregations of closed mesopores. Zoœcial apertures small, floriform, about sixteen in 3 mm., separated by interspaces, in which but few mesopores can be detected, of less width than their diameter; each surrounded by from five to seven small acanthopores, projecting well into the zoœcial cavity. This describes the fully matured and ordinary appearance of well preserved specimens. Young stages are quite different, the zoœcial apertures being a little larger, angular, with very thin walls, and while the mesopores are readily distinguishable and one or two to each zoœcium, the acanthopores are so small as to be practically wanting.

Internal characters: To obtain the fully matured characters of this species it is necessary to make the tangential section as nearly superficial as possible. In this outermost region the zoœcial wells are of moderate thickness and inflected more or less strongly at the points occupied by the acanthopores. The mesopores here appear as mere irregular interstices between the rounded walls of the zoœcia. At deeper levels in the section the acanthopores become smaller and at last indeterminable, the zoœcia prismatic and their walls thin, and the mesopores more distinct. The appearances now are just as in transverse sections of the axial region. Vertical sections show that cystiphragms and diaphragms are developed throughout the tubes from their origin in the axial region to their superficial orifices. These structures are, however, a little more closely arranged near the surface of the zoarium than in the axial region. Mesopores are likewise present in both regions, but these seem gradually to expand as they bend out of the axial region and to assume the characters of true zoœcia. At the same time new mesopores are interpolated, but these do not develop into zoœcia. On the contrary the tendency is to close them up by deposit on the zoœcial walls.

This is the second species of the genus in which the zoarium rises into the ramose form. The first is the *A. newportensis* Ulrich, from the lower beds of the Cincinnati group at Newport, Ky. The latter has larger monticules, more numerous mesopores, less abudant acanthopores, and thinner zoœcial walls. The ramose habit of growth will distinguish it from the other species of the genus. Several species externally similar, but internally widely different, occur in the same beds with *A. ramosa.* One of these is the *Callopora pulchella*, var. *persimilis,* another is the *Homotrypa tuberculata* of the present work, while a third is the *Batostoma montuosum.* With a little practice these will be distinguished readily enough, even without the aid of thin sections. When the surface is a little worn the student may find it difficult to separate the species from montiferous examples of *Monticulipora arborea,* a species found chiefly in the overlying Galena shales. When both are in a good state of preservation he will find that the walls of the *Monticulipora* are somewhat thicker and much more minutely granulose, and that true mesopores are wanting.

Formation and locality.—Upper third of the Trenton shales, near Cannon Falls, Minnesota, where it is associated with an abundance of *Prasopora conoidea* and *Phylloporina corticosa.*

Genus HOMOTRYPELLA, Ulrich.

Homotrypella, ULRICH, 1886. Fourteenth Ann. Rep. Geol. and Nat. Hist. Surv. Minn., p. 83.

Zoarium somewhat irregularly ramose, occasionally palmate or frondescent; monticules wanting, but small maculæ, consisting of clusters of mesopores, often present. Zoœcia with rounded apertures, the latter sometimes inflected by the acanthopores. Mesopores small, abundant, in some cases completely isolating the zoœcia. Acanthopores abundant, of medium size, generally imparting to the surface a minutely granulose character. Cystiphragms developed chiefly in the median region of the zoœcial tubes, being absent usually just beneath the surface and never present in the axial region.

Type: *H. instabilis* Ulrich.

This genus was established for the reception of a small but eminently natural group of Lower Silurian species that could not be included in any of the other genera of the family. Since then other forms have been discovered, and the classification of several others changed, so that now no less than eleven, perhaps twelve, species of the genus are known to me. These range from the Birdseye to the top of the Lower Silurian, each of the more important subdivisions containing one or more species.

In the ramose habit of growth the genus resembles *Homotrypa* Ulrich, but the abundant mesopores are a distinguishing mark of some importance. A comparison with *Peronopora* Nicholson, and *Atactoporella* Ulrich, shows the following differences: In the first the zoaria are bifoliate, in the second usually parasitic, and in both the cystiphragms are developed in an almost uninturrupted series throughout the length of the zoœcial tubes.

Fuller investigations into the affinities of these fossils have shown good grounds for redistributing the species heretofore referred to *Batostomella*. That genus must, therefore, be restricted to the Devonian and Carboniferous species originally intended as types.* This leaves the Lower Silurian species unplaced generically. Since large specimens of *B. gracilis* Nicholson, and many of the ordinary forms of *B. meeki* James, sp., from the Cincinnati group of Ohio, often have a few cystiphragms developed in the curve of the tubes, and as their other characters are in no wise strongly opposed to a union with *Homotrypella*, it seems best, at any rate provisionally, to place them here. However, the *B. simulatrix* Ulrich, group of species cannot be admitted, and to accommodate them a new generic name will have to be proposed.

**Trematella*, Hall, 1887, Pal. N. Y., vol. vi, p. 14, is evidently a synonym of *Batostomella*, Ulrich, 1882, Jour. Cin. Soc. Nat Hist., vol. v, p. 154.

The latter continue into the Lower Helderberg and may really be the stock that eventually produced *Batostomella annulata* (*Trematella annulata* Hall) and *B. perspinulata* Hall, sp., of the Devonian, and *B. spinulosa* Ulrich, the Chester type of the genus. But I am satisfied that the *gracilis* group, indeed the whole genus *Homotrypella,* did not survive into the Niagara.

HOMOTRYPELLA INSTABILIS *Ulrich.*

PLATE XVIII, FIGS. 9-20.

Homotrypella instabilis ULRICH, 1886. Fourteenth Ann. Rep. Geol. and Nat. Hist. Surv. Minn., p. 83.

Zoarium ramose, growth rather irregular; branches rounded, sometimes nodular or lobate, and varying in diameter from 3 to 8 mm.; surface generally without monticules, and when these are present they are low and broad; small maculæ or clusters of mesopores are not infrequently present. Superficial characters of zoœcia and mesopores variable. In some, and these are in most cases well-preserved examples, the zoœcial apertures are irregular both in form and arrangement, with thin walls, partly separated by mesopores numbering one or two to each zoœcium. In these specimens the acanthopores are small yet prominent and sharp, and number from one to three to each zoœcium. The mesopores are always smaller than the zoœcia, but vary occasionally in shape, size and arrangement. In many other examples both the zoœcia and mesopores are smaller and their walls correspondingly thick, while the acanthopores are blunt and thicker. In most cases a little wearing suffices to obscure the mouths of the mesopores, so that they are readily overlooked. Twelve or thirteen of the zoœcia occur in 3 mm.

Internal characters: As may be seen by comparing figures 13 and 14 with 18 and 20 (plate XVIII) tangential sections of this species present an unusual variety of appearances. In the majority of sections, providing they are not too deep, the walls of the cells are very thick, with not a sign of cystiphragms in the zoœcial cavities. When a second or peripheral series of cystiphragms has been developed (see figs. 17–20) a very different appearance is obtained. Now the walls are thinner, and a cystiphragm, leaving from one-third to one-half of the zoœcial cavity open, is to be seen in each of the zoœcia. In all cases the polygonal lines of contact between the two sets of cells is sharply defined, and the walls of both approximately of equal thickness. The acanthopores are conspicuous features of these sections, but their relative abundance varies somewhat in different examples. In the axial region of vertical sections the walls of the tubes are very thin and finely wavy, and the diaphragms straight and remote, or wanting entirely. As the tubes enter the peripheral region the number of diaphragms is greatly increased, the walls thickened, and cystiphragms, mesopores and acanthopores developed. The mesopores are distinguished from the zoœcia by their shortness and in having no cystiphragms. The latter structures number from three or four to fifteen in a direct series in each zoœcial tube. In most cases they occur only in the region intervening between the fully matured peripheral and the immature axial region. Beyond them the diaphragms are crowded and essentially horizontal. In the mesopores the diaphragms are often thick and situated about the same distances apart as in the zoœcial tubes, with from fourteen to seventeen in 1 mm. In the axial region of transverse sections the zoœcial tubes are of unequal sizes and of peculiarly irregular shapes.

Formation and locality.—Rather abudant in the middle third of the Trenton shales, at St. Paul. Minneapolis, Cannon Falls, near Fountain, and other localities in Minnesota.

Mus. Reg. Nos. 5025, 5981, 5982.

HOMOTRYPELLA MULTIPORATA, *n. sp.*

PLATE XVIII, FIGS. 21, 22.

Zoarium ramose, branches cylindrical, 8 or more mm. in diameter. Zoœcia small, about twelve in 3 mm., with thin walls, rounded or petaloid apertures, their margins raised slightly and separated by a conplete ring of small mesopores. Acanthopores small, numerous. Cystiphragms seen only in the turn of the zoœcial tubes, as far as observed, varying between two and six in each tube. Diaphragms in zoœcial tubes exceedingly delicate, five or six in 1 mm.; a little stronger in the mesopores, and here numbering about nine in each tube; apparently wanting in the axial region, where the tube walls are minutely crenulate and thin. In the axial region of transverse sections the tubes are very unequal.

This species, so far as observed, forms thicker branches, has much more numerous mesopores, and smaller and thinner-walled zoœcia than its associate *H. instabilis.* Internally the diaphragms are wider apart in both sets of tubes and more delicate. They differ again in being twice as numerous in the mesopores as in the zoœcial tubes. None of the other species are sufficiently related to require comparisons.

Formation and locality.—Rare in the middle third of the Trenton shales, at St. Paul and Minneapolis, Minnesota.

HOMOTRPELLA (?) SUBGRACILIS, *n. sp.*

PLATE XXVI, FIGS. 10-16.

Zoarium small, ramose, dividing irregularly; branches subcylindrical, 2 to 4.5 mm. in diameter; surface without monticules and maculæ. Zoœcia rather irregular in size, shape and arrangement, varying also in the thickness of their walls, these being often stronger than shown in figs. 15 and 16, plate XXVI; twelve or thirteen in 3 mm. Apertures oblique in some of the young examples, nearly or quite direct in the others; in the latter the numerous small acanthopores cause more or less irregularity in the outline of the apertures. Mesopores of unequal sizes, irregular in arrangement, scarcely more numerous than the zoœcia, from which it is sometimes difficult to distinguish some of the larger ones.

Internal characters: These are but illy preserved in the two sets of sections prepared, and all the characters shown in them are brought out in figs. 10, 11 and 12, on plate XXVI. Four vertical sections fail to exhibit any positive evidence of either diaphragms or cystiphragms, the tubes appearing as open throughout. This condition, however, seems unnatural and probably due to imperfect preservation. There should be some transverse partitions in the tubes, though these, especially the cystiphragms, must have been comparatively few in this species. A similar absence of diaphragms, in this case obviously due to imperfection, is sometimes met with in sections of *H. gracilis* (*Chætetes gracilis* Nicholson), of the Hudson River rocks, which the present species is believed to resemble more than any other. And yet I am satisfied that, when sufficiently good material can be studied, the internal characters will prove equally as near to those of the associated *H. instabilis*, with which I had at first confounded it.

Formation and locality.—Rather rare in the middle third of the Trenton shales, at Minneapolis and St. Paul, Minnesota.

HOMOTRYPELLA (?) OVATA, *n. sp.*

PLATE XVIII, FIGS. 23-30.

Zoarium small, ramose, branches generally compressed, sometimes subcylindrical, varying between 2 and 5 mm. in diameter or width, dividing at unequal intervals. Surface without monticules, but exhibiting at intervals of 2 or 3 mm. clusters of cells of larger size and more widely separated than the average. Zoœcial apertures rounded, commonly a little oblique, oval and enclosed by a thin but slightly elevated peristome on which a single small acanthopore is in most cases to be detected, though generally with some difficulty. Interspaces depressed, with the mouths of the rather large mesopores occupying them, closed or open, probably according to the state of preservation. The zoœcial rims are nearly always in contact with each other at limited points, yet many individual zoœcia, especially of those in the clusters mentioned, may be completely separated from their neighbors by mesopores. In some specimens, preserved unusually well, the interspaces are granulose, the granules seeming to form rows on the walls separating the mesopores. Long diameter of average zoœcium 0.17 mm.; some of the largest in the clusters 0.25 to 0.30 mm.; ten to twelve in 3 mm.

Internal characters: Vertical sections show that the peripheral region is narrow, that here, and in the turn of the zoœcial tubes, the diaphragms are closely arranged, with from six to eight in 0.5 mm. Just in the turn of the tubes, along the upper wall, one, two or three cystiphragms were developed. The mesopores begin at the same point, and in these the diaphragms are more crowded and thicker. In the central part of the axial region the tubes are larger than farther out, and intersected by diaphragms at intervals of about 0.5 mm. In nearing the surface the tubes become narrower and the diaphragms closer. Tangential sections are distinctive in showing the wide interpaces, large and sharply-defined mesopores, and the ring-like definition of the zoœcial walls. In most cases the zoœcia are completely separated or rarely touch each other without sacrificing any of their roundness of outline.

Compared with other species, the *Homotrypa ? intercalaris* of this work seems to be the nearest and distinguished chiefly in vertical sections, diaphragms being absent in the axial region of that species and cystiphragms more numerous in the peripheral. For further remarks on this relationship, see p. 216. For comparisons with *H. mundula*, see under that description.

Formation and locality.—Galena shales, near Cannon Falls, Minnesota. Two fragments from the middle Trenton shales at Minneapolis seem to be identical in nearly every respect, but so far the species has not been found in the upper third of the shales intervening between these two horizons.

Mus. Reg. No. 8124.

HOMOTRYPELLA MUNDULA, *n. sp.*

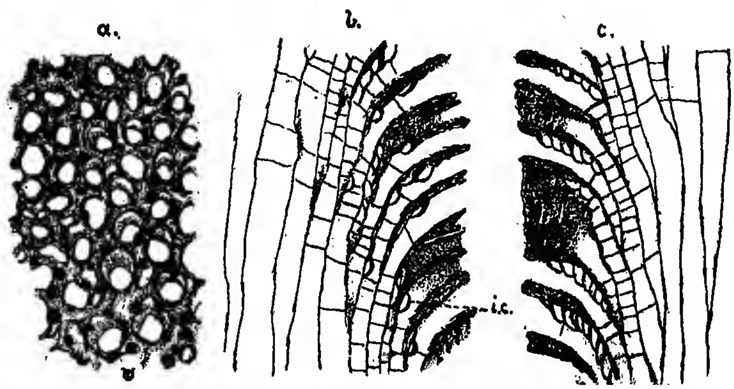


Fig. 12. *Homotrypella mundula* Ulrich, Galena shales, Decorah, Iowa.
a, tangential section; *b* and *c*, opposite sides of a vertical section, showing differences in the number of cystiphragms; all x 18.

Zoarium dendroid, branches subcylindrical, small, 2.5 to 5.0 mm. in diameter, dividing, generally dichotomously, at irregular intervals. Monticules wanting, but in most cases clusters of zoœcia, slightly larger and more widely separated than the average, are to be distinguished. Zoœcial apertures somewhat irregularly distributed, ten to twelve in 3 mm., slightly oblique in young stages, ovate or irregular in shape, in the best preserved examples more or less obscured by the rather large and abundant projections of the acanthopores. Interspaces varying, even in small spaces, from contact between the zoœcial walls to a width fully equalling the diameter of a zoœcium. Where widest they are depressed, and in a few instances show the mouths of mesopores, but as a rule these appear as closed solidly.

Internal characters: In the axial region of vertical sections the tubes sometimes appear to have grown irregularly, and where this is the case they are intersected by a few remote diaphragms. However, in the normally developed straight tubes, these structures are wanting in the axial region except in zones, 2 or 3 mm. apart, extending through the branches. In these each tube has a few. Such a zone is shown in the upper part of figs. *b* and *c*. As the tubes turn to enter the peripheral region, diaphragms become numerous, and in their midst a series of cystiphragms is developed in most of the tubes. The development of the cystiphragms is not uniform, being, as shown at *i. c.*, fig. *b*, often isolated, while in other cases they may form continuous series of as high as ten or twelve. Such extremes may be noted in a single section, and it seems evident that in the development toward *H. gracilis* Nicholson, sp., they had by this time lost some of their importance and were gradually being dropped. The mesopores are inconspicuous features in vertical sections, being filled almost solidly with sclerenchyma in which their diaphragms are but illy distinguishable.

In tangential sections the zoœcia commonly present a dark ring-like investment, in which the sharply defined acanthopores are mostly situated. The interspaces are of a lighter color, and but rarely exhibit any positively defined mesopores. Cystiphragms, so far as observed, may be detected in perhaps half of the zoœcia.

A closely related but smaller species than *H. granulifera* (*Chætetes granuliferus* Ulrich) from the Trenton of Kentucky. In its general aspect it is exceedingly like *H. gracilis* Nicholson, sp., of the Hudson River rocks, and it is almost certain that the two represent stages in one line of development. However, comparative abundance of cystiphragms in the present species will distinguish them at once, these structures being of very rare occurrence in *H. gracilis*. In the latter the acanthopores also are smaller, so that the surface granulation is less coarse.

Formation and locality.—Galena shales. Common at Decorah, Iowa; rare in the vicinity of Cannon Falls, Minnesota.

Mus. Reg. No. 8080.

HOMOTRYPELLA RUSTICA, *n. sp.*

PLATE XVIII. FIGS. 31-33.

Zoarium irregularly ramose, branches 5 to 10 mm. in diameter. Low swellings of the surface, scarcely to be called monticules, occasionally present. Surface very rough under a hand lens, the acanthopores being strong and numerous, though not materially inflecting the zoœcial walls. Zoœcial apertures rounded, about eleven in 3 mm. Mesopores abundant, though but rarely separating the zoœcia completely, of unequal sizes, rounded at the surface.

Internal characters: In tangential sections, showing the characters immediately beneath the surface, (upper part fig. 32) the zoœcia are rounded, with only moderately thick walls, the mesopores sharply defined, subangular, of unequal sizes, and averaging three or four to each zoœcium, the acanthopores strong, perhaps two to each zoœcium, and situated chiefly in the zoœcial walls, which they occasionally only cause to bend inwardly. At a deeper level (lower part fig. 32) the walls are thinner, the acanthopores smaller, and the mesopores larger. At both levels the zoœcia almost uniformly exhibit the cut edges of cystiphragms. In vertical sections the most striking feature of the species is the abundant tabulation of all the tubes. Diaphragms occur all through the axial region, and both the mesopores and acanthopores began earlier than usual. The outward curving of the tubes also is unusually gradual. The diaphragms in the two sets of tubes are subequally distributed, and it is often difficult to discriminate between them when the curved edges of the cystiphragms are not shown. At about the middle of the curve nine or ten diaphragms occur in 1 mm.; nearer the surface they are a little closer, while more toward the center of the branch they are further apart. The cystiphragms are unusually superficial in this species, forming crowded series almost to the mouths of the zoœcia.

This species is distinguished from *H. granulifera* and *H. mundula* by the greater number and open character of the mesopores; from *H. multiporata* by its larger zoœcia, fewer and more unequal mesopores, and more crowded as well as different tabulation of the tubes. *H. instabilis* has thicker walls, and is quite different in other respects.

Formation and locality.—The sections illustrated were prepared from a single example collected by the author in the upper beds of the Hudson River group, at Spring Valley, Minnesota. This specimen seems identical with a common species occurring at an equivalent horizon in Indiana and Ohio, to which I had applied the name *rustica* in my MS. notes.

Mus. Reg. No. 8125.

Genus HOMOTRYPA, Ulrich.

Homotrypa, ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 240; 1890, Geol. Surv. Ill., vol. viii, pp. 370 and 409; 1883, FOORD, Contri. Micro-Pal, Can., pt. I, p. 9.

Zoaria erect, generally ramose, at other times frondescent, with or without monticules. Zoœcial tubes with very thin and finely crenulated walls and remote diaphragms in the axial region. Cystiphragms, isolated or in series, developed in the peripheral region only. Apertures polygonal or subcircular, the shape depending upon the thickness of the walls and the character of the interspaces. Mesopores occasionally wanting, typically few and gathered into clusters; in several aberrant cases (*e. g. H. separata*), comparatively numerous and causing a greater or less separation of the zoœcial walls. Acanthopores usually present, of varying sizes. What appear to be large communication pores have been detected under favorable circumstances in several species.

Type: *H. curvata* Ulrich, Hudson River group.

This is the largest and one of the best characterized genera of the *Trepostomata.* Adding the new forms here proposed we have a total of seventeen described species. There are at least six more to be published from the Hudson River Rocks of Ohio and Indiana alone, while as many more are known to me from various Lower Silurian horizons in Tennessee, Illinois, Wisconsin and Minnesota.

The affinities of the genus, as indicated by species like *H. intercalaris*, are with *Homotrypella;* others resemble *Eridotrypa*, while some again are not easily distinguised from erect forms of *Monticulipora* like *M. arborea* and *M. molesta* Nicholson. In this connection it would be well to read the remarks on pp. 215 and 216.

HOMOTRYPA MINNESOTENSIS *Ulrich.*

PLATE XIX, FIGS. 1-9.

Homotrypa minnesotensis ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 79.

Zoarium ramose, branches subcylindrical, from 5 to 15 mm. in diameter, generally dividing dichotomously at long intervals, rarely inosculating. In the typical form monticules are not developed, but the clusters of large cells are conspicuous. In a later variety, commonly also of larger size than the typical form, these clusters are often raised into prominent monticules, about 2.5 mm. from center to center. Central part of these groups often appearing subsolid or with shallow mesopore-like depressions in the interspaces. True mesopores wanting. Acanthopores exceedingly small and few, observed only in thin sections. Ordinary zoœcia angular, with thin walls and more or less oblique apertures. In young examples the obliquity is very great, while it is only in the largest that the apertures can be said to be direct. About twelve of the average zoœcia in 3 mm. In the large monticulose variety, already mentioned, and which may be designated as var. *montifera*, there are thirteen apertures in the same space.

Internal characters: In vertical sections the peripheral or "mature" region is very narrow, and the axial region, in which the tubes are long and nearly vertical, correspondingly large. In the latter diaphragms are wanting, and the walls extremely thin and wavy. Near the surface the walls are appreciably thickened, but never enough to be described as otherwise than thin. The curve of the tubes throughout is unusually gentle. Diaphragms and cystiphragms set in abruptly and their arrangement in the tubes is shown better in figs. 1, 5 and 6 than it can be described.

Owing to the obliquity of the zoœcial apertures it is difficult to prepare satisfactory tangential sections of any except large and old examples. The successful ones show that the zoœcial walls are comparatively thin, that a few mesopore-like cells are sometimes interpolated between the zoœcia, and that the acanthopores are so small and few that they are readily overlooked. Nor are the cystiphragms conspicuous in these sections.

Transverse sections are interesting chiefly because they show the unusual narrowness of the peripheral region, and the decrease in size and flattening of the tubes as they enter this part of the zoarium.

This species is distinguished from all the others of the genus known from the Trenton by its oblique zoœcial apertures.

Formation and locality.—Common in the lower third of the Trenton shales, at Minneapolis, St. Paul, Cannon Falls, Preston, Fountain and other localities in the state. It has not been certainly identified in the middle third of the shales, but in the upper third, at St. Paul, a large form of this species occurs associated with the var. *montifera* in considerable abundance. The species is also known from Decorah and other localities in Iowa.

Mus. Reg. Nos. 5970, 5975, 7600.

HOMOTRYPA EXILIS *Ulrich.*

PLATE XIX, FIGS. 10-16.

Homotrypa exilis ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 80.

Zoarium ramose, branches slender, without monticules, cylindrical, 3 to 5 mm. in diameter (generally 4 mm.), dividing at long intervals. Entire hight of zoarium less than 75 mm. Zoœcia with rounded, direct apertures and moderately thick walls, about twelve in 3 mm. Clusters of cells larger than the average occur, but do not constitute a conspicuous feature. Mesopores comparatively numerous, especially in the clusters just mentioned. Diaphragms wanting in the axial region, but present in the short and rather abruptly bent peripheral region, in which the walls are also thickened and a series of cystiphragms developed.

This clearly is not the young of *H. minnesotensis*. The specimens viewed under a hand lens show more direct and rounder zoœcial apertures, with the mesopores also more abundant, and on the whole have a more matured appearance than many much larger specimens of that species. Furthermore, the zoœcial walls in the larger species never get to be as thick as has been observed in sections of *H. exilis*.

Formation and locality.—Not uncommon in the lower third of the Trenton shales at Minneapolis, Minnesota.

Mus. Reg. Nos. 5976, 7655.

Homotrypa separata, *n. sp.*

PLATE XIX, FIGS. 17-20.

In its growth and, with the exception of one feature, also in its internal characters, this species is very similar to *H. minnesotensis*. As it also occurs in the same beds with that species, a detailed description is unnecessary. A comparison of the two forms brings out that *H. separata* has an abundance of mesopore-like depressions at the angles of junction between the zoœcia, with aggregations of such depressions in the maculæ (see fig. 19), causing the zoœcial apertures to be rounded—commonly subcircular instead of angular. Internally these interspaces give, to tangential sections especially, a very different appearance from those of *H. minnesotensis* (compare figs. 3 and 4 with 17 and 18, plate XIX). Vertical sections of the two species are more alike, the only difference worthy of notice being the numerous presence of mesopores in the one and almost total absence in the other. Despite the obviousness and, in most other cases, the importance of a difference like that existing between these two forms, I cannot doubt that they are in reality closely related.

Formation and locality.—Lower third of the Trenton shales at Minneapolis, Chatfield, and near Preston, Minnesota.

Mus. Reg. Nos. 7667, 8122.

HOMOTRYPA (?) INTERCALARIS, *n. sp.*

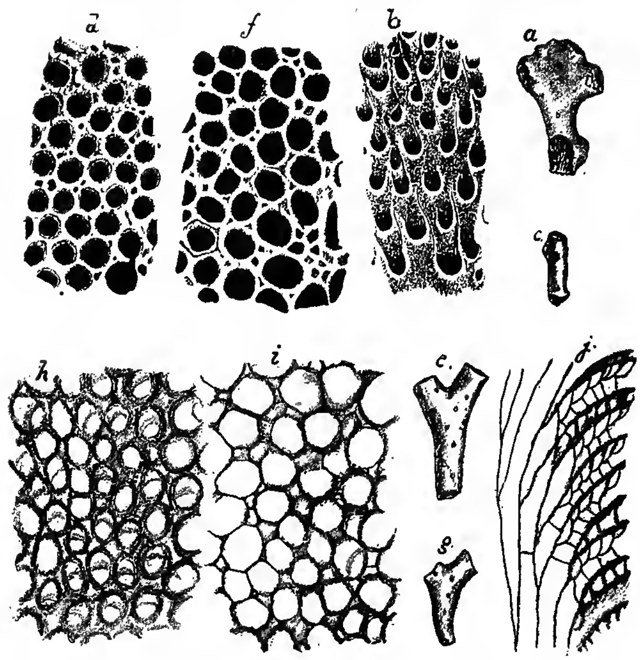


FIG. 13. *Homotrypa* (?) *intercalaris, n. sp.*, middle Trenton shales, Minneapolis, Minnesota. Collection of E. O. Ulrich. *a* and *b*, a specimen of the natural size, and small portion of its surface x18, showing unusually oblique zoœcial apertures; *c* and *d*, similar views of a fragment of a form doubtfully referred to this species, having somewhat smaller zoœcia and mural papillæ; *e* and *f*, similar views of a typical example; *g*, more slender fragment, natural size; *h*, tangential section, x18, showing structure immediately beneath surface of fully matured example; *i*, another portion of same section, showing structure at a deeper level; *j*, vertical section, x18, showing the peripheral region with the mesopores and cystiphragms, and a small part of the untabulated axial region.

Zoarium small, ramose, branches subcylindrical, generally 2.5 to 3.5 mm. in diameter. Surface without monticules but exhibiting distinct clusters of large cells in the centers of which there is often a small aggregation of mesopores. Zoœcial apertures rounded or subangular, commonly direct to the surface, at other times more or less oblique, occasionally so much so (see fig. 13 *b*) that they recall those of *Ceramoporella.* The last condition probably occurred only when a new layer of zoœcial tubes was developed in which the individual cells failed to correspond exactly with those of preceding layers. Typical form with about thirteen zoœcia in 3 mm.; the variety, also figured above, has fifteen in the same distance. Walls or interspaces of moderate thickness, commonly with very few and inconspicuous acanthopores. But in the variety a row of minute papillæ has been observed along the center of the wall. Mesopores rather abundant, occurring at most of the angles of junction between the zoœcia.

The internal structure is brought out sufficiently in the accompanying cut. Figures *h* and *i* show how very similar tangential sections may be to those of the later *Homotrypella* (?) *ovata*, illustrated on plate XVIII. The mesopores are on the whole smaller and do not separate the zoœcia so completely, and sometimes the difference in these respects is greater than is shown in the illustrations. The difference between vertical sections of the two forms is better marked, the cystiphragms being more numerous and diaphragms wanting in the axial region in the present species. *Homotrypa exilis* is another closely allied form, but differs in the opposite manner, the mesopores being fewer (see plate XIX).

This is an important stage in the line of development discussed on page 216.

Formation and locality.—Middle third of the Trenton shales at St. Paul and Minneapolis, Minnesota.

Homotrypa subramosa *Ulrich.*

PLATE XIX, FIGS. 21-28.

Homotrypa subramosa Ulrich, 1886. Fourteenth Rep. Geol. Nat. Hist. Sur. Minn., p. 81.
Homotrypa insignis Ulrich, 1886. Fourteenth Rep. Geol. Nat. Hist. Sur. Minn., p. 82.

Zoarium subramose, frequently though irregularly divided; branches compressed or subcylindrical, their extremities often bulbous. Size of branches varying greatly, the smallest 4 or 5 mm. in diameter, the largest 6 to 9 mm. thick, and as much as 25 mm. wide. Average specimens are about 6 mm. thick and between 8 and 12 mm. wide, with the total hight of zoarium rarely exceeding 60 mm. Surface without monticules, nor are the clusters of large cells very conspicuous. Zoœcia with rather thin walls and polygonal, direct apertures; twelve to fourteen in 3 mm. Zoœcial apertures shallow, exposing the cystiphragms when in a good state of preservation. These structures leave but a small opening, and when the fossil has suffered a little from attrition (a frequent occurrence in the beds holding the species most abundantly) in which case the true walls are obscured or cut away, the appearance is very deceptive, the apertures seeming to be very small and oblique, and much the greater part of the surface occupied by wall-substance. Acanthopores varying in number and size, sometimes as numerous as two to each zoœcium. More commonly the number is little more than half that extreme. In many cases they are large enough to constitute a marked external feature. In others, however, apparently in an equally good state of preservation, they are so small that it is difficult to detect them even with the aid of a good lens.

Internal characters: Vertical sections show that the tubes proceed in a gradually increasing curve from the axial region outward to the peripheral region, in which they are approximately at right angles to the surface; that in the axial region the tubes are rather large, with wavy walls, and crossed by straight or oblique diaphragms, either in zones or occurring at intervals varying from one to three times their diameter; that in the peripheral region the walls are moderately thickened, and the tubes occupied by a gradually crowding series of cystiphragms. The varying appearances of tangential sections are sufficiently exhibited in figs. 22 to 25. The differences so far observed in these sections consist almost entirely of variations in the number and size of the acanthopores.

Greatly increased collections, and the study of numerous sets of thin sections, have convinced me of the specific identity of *H. subramosa* and *H. insignis.* The latter name might be retained in a subordinate sense for the Galena shales variety, in which the clusters of large cells are more conspicuous, the average size of the zoarium smaller, the zoœcial walls thinner, and the acanthopores permanently less numerous and smaller than in the typical middle and upper Trenton shales form of the species.

The tabulated axial region, more numerous and larger cystiphragms, the presence of acanthpores, and the irregular and more compact growth, will distinguish the species from preceding forms of *Homotrypa.* Thin sections will of course separate it at once from outwardly more similar species, belonging to other genera, that are associated in the same beds.

Formation and locality.—*H. subramosa* is rare in the middle third of the Trenton shales at several localities in St. Paul and Minneapolis, but is much more abundant in the upper third of the shales at St. Paul and localities in Goodhue county, Minnesota. The restricted var. *insignis* is comparatively rare in the Galena shales at localities in Goodhue and Fillmore counties; also in the same beds at St. Paul, and at Decorah, Iowa.

Mus. Reg. Nos. 5977 to 5980, 8030, 8061.

HOMOTRYPA TUBERCULATA, *n. sp.*

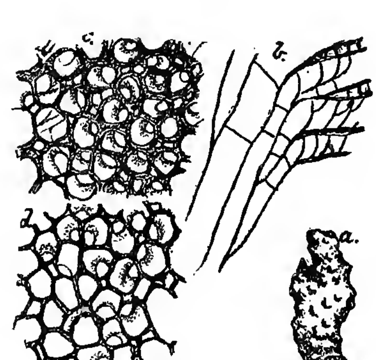


FIG. 14 *Homotrypa tuberculata*, n. sp., upper third Trenton shales, near Cannon Falls, Minnesota. Collection of E. O. Ulrich. *a*, fragment of the natural size; *b*, small portion of a vertical section, x 18, showing two mesopores, the cystiphragms and diaphragms of the peripheral region, all of which are wanting in the axial region; *c* and *d*, two portions of a tangential section of a fully matured example, x 18, the former showing appearance immediately beneath the surface, the latter at a slightly deeper level.

Zoarium small, ramose, branches rounded or flattened, dividing rather frequently, 2.0 to 3.5 mm. thick, and 2.5 to 7.0 mm. wide. Surface more or less strongly tuberculated, the monticules 2 to 2.5 mm. apart, conical, often very prominent. Zoœcial apertures nearly fourteen in 3 mm., angular or rounded, more or less oblique except in the oldest examples, in most specimens exposing the cystiphragms. Walls thin, often separating so as to form considerable interspaces in which a greater or less number of closed mesopores is contained. The extent of these interspaces varies greatly, being sufficient in some instances to cause the zoœcial apertures to be of rounded or ovate form, while in other specimens they are scarcely appreciable. Acanthopores small, about one to each zoœcium.

Internal characters: In vertical sections the tubes are large and without diaphragms in the axial region, the latter, together with short and rather irregular series of cystiphragms, being developed in the narrow peripheral region only. The mesopores appear as shown in the figure. Of tangential sections it would be possible to select small portions differing so much from each other in the number of mesopores that they would scarcely be suspected of belonging to one species. Still, if the sections are large enough each will contain some parts that may be said to be practically the same as those represented in figs. *c* and *d*. The acanthopores, though small and few, are quite distinct in these sections.

This is another of those aberrant forms of the genus like *H. intercalaris.* While its relations seem often to be decidedly suggestive of *Homotrypella* (?) *ovata,* I do not believe that its development resulted in that form. It seems to be an offshoot, perhaps from that line, which latter produced the *H. obliqua* Ulrich, of the Cincinnati group.

The strong monticules distinguish the species from the Trenton forms of the genus. Associated with it there are two really very distinct though dangerously similar species. The first of these is the *Atactoporella ramosa* with its numerous acanthopores and inflected zoœcial apertures, and totally different internal structure. The second, *Callopora persimilis,* differs so widely in its internal structure that it will be sufficient to refer the student to the figures on plate XXII. Other species presenting more or less superficial resemblance might be mentioned, but I cannot regard it as necessary, since with the aid of thin sections the student will have no trouble in distinguishing them.

Formation and locality.—Upper third of the Trenton shales, near Cannon Falls, Minnesota. The species probably occurs in the same beds at St. Paul.

Mus. Reg. No. 8123.

HOMOTRYPA SIMILIS *Foord.*

PLATE XX, FIGS. 28-33.

Homotrypa similis FOORD, 1883. Contri. Micro-Pal. Cambro-Sil. Rocks, Canada, p. 10.

Zoarium of medium size, ramose, the branches subcylindrical or compressed, 4 to 10 mm. in diameter, dividing at unequal intervals, often irregularly, occasionally even anastomosing. Surface without monticules, but usually exhibiting well marked substellate spots, consisting of aggregations of large, thick-walled cells, in many cases surrounding a minutely granulose central space. Zoœcial apertures more or less oblique, the degree depending upon age, appearing thin-walled and angular when in a good state of preservation, but much smaller and ovate, and seemingly with much thicker walls, when slightly worn; about twelve in 3 mm. Mesopores wanting, acanthopores small, inconspicuous superficially. When perfectly preserved the walls are minutely granulose.

Internal characters: Tangential sections will present a variety of appearances depending upon the age of the specimen sectioned, and the distance from the surface. In the central or deeper parts of a section prepared from an old example (plate XX, fig. 32), the zoœcia have thin walls, each will have a well-defined cystiphragm, or, if too deep to show the end walls distinctly, will be crossed by three or four straight and curved lines, representing both cystiphragms and diaphragms. From this condition we pass gradually into stages in which the walls are thickened, the cystiphragms filled up more or less completely and their ends drawn out and around so as to enclose a comparatively small ovate open space. At the same time the walls assume a minutely granular character, while at many of the angles of junction a larger dark spot (acanthopore) is to be detected. These stages are illustrated in figures 32 and 30. The lower half of the latter represents an unusual condition, in having the original wall undefined. It should be remembered that very few sections will show more than the first stage, and that, on account of the brevity of the peripheral region and the obliquity of the zoœcial tubes, it is at all times rather difficult to prepare really satisfactory tangential sections.

Figures 29 and 31 illustrate vertical sections taken from fully matured examples, the first from Canada, the second from Minnesota. These and other sections show that the tubes bend outward very gradually; that they are tabulated throughout, with the diaphragms from one to three times their diameter apart in the axial region. As they near the periphery the diaphragms become oblique and curved and then pass over into series of cystiphragms and short, crowded diaphragms, with from twelve to sixteen of the latter in 1 mm. The most peculiar feature of the species, perhaps, is the solid filling of the cystiphragms near the surface. This is, however, a peculiarity that is not shown to advantage except in sections of old examples.

Foord's figures of this species (*op. cit.*) are not entirely satisfactory, though sufficiently so to make the identity of the Minnesota examples referred to it a matter of high probability. Still, in making the identification I relied chiefly upon the characters of a Canadian example kindly furnished me by the author of the species.

The obliquity of the zoœcial apertures, and the substellate surface spots will serve to distinguish the species from associated forms, while its peculiar internal structure separates it from all others known to me. The affinities of the species are somewhat doubtful, but it is certainly not related very closely to *H. obliqua* Ulrich, of the Cincinnati group.

Formation and locality.—The types are from the Trenton limestone at Ottawa, Canada. In Minnesota the species is an abundant fossil in the Galena shales, in the upper beds especially, at several localities in Goodhue county, and at St. Paul, Minnesota.

Mus. Reg. Nos. 7636, 8021, 8043, 8058.

HOMOTRYPA CALLOSA, *n. sp.*

PLATE XX, FIGS. 15-21.

Zoarium irregularly ramose, less than 80 mm. high; branches generally somewhat compressed, 6 to 12 mm. wide, 5 to 10 mm. thick. Surface with moderately distinct clusters of large cells, sometimes raised into low monticules. Zoœcial apertures subangular, nearly or quite direct, enclosed by rather thick, ridge-shaped walls; thirteen or fourteen in 3 mm. Mesopores wanting. Acanthopores small, inconspicuous superficially.

Internal characters: In tangential sections the most striking features are (1) the thickness and minute structure of the walls (see figs. 16 and 21) and (2) the comparative straightness of the inner edge of the cystiphragms. In the Minnesota specimens the latter seem to project a little farther across the zoœcial cavity, while the walls are uniformly a little heavier and the zoœcia sometimes a trifle larger than in the Kentucky form.

In vertical sections the tubes bend outward gradually, and are tabulated throughout, remotely and irregularly in the axial region, where only diaphragms occur, and more crowded, also consisting chiefly of cystiphragms, in the peripheral region. On plate XX, fig. 19 shows the character of the tubes near the center of the branch, while figs. 17 and 18 illustrate their usual appearance in the outer fourth of the diameter. In other parts of the same sections the short diaphragms crossing the tubes from the series of cystiphragms to the opposite wall, are still preserved almost to the surface. That they are often wanting, as shown in the figures, is probably due to imperfect preservation.

This species is clearly distinct from all the preceding. Its relations seem to be with *H. curvata* of the Cincinnati group. Superficially it resembles *Monticulipora arborea* Ulrich, a form that is associated with it not only in Minnesota but also in Kentucky. That species is separated by its smaller cells and finely granulose walls. Internally they are quite distinct.

Formation and locality.—Galena shales, near Cannon Falls, Minnesota; shales of the Trenton group at Burgin and Frankfort, Kentucky.

Genus PRASOPORA, Nicholson and Ethridge, jun.

Prasopora, NICHOLSON and ETHRIDGE, jun., 1877, Ann. and Mag. Nat. Hist., ser. 4, vol. xx, p. 38; 1879, NICHOLSON, Pal. Tab. Corals, p. 324, and 1881, "Genus Monticulipora," pp. 102 and 202; 1882, ULRICH, Jour. Cin. Soc. Nat. Hist., vol. v, p. 153, and 1890, Geol. Surv. Ill., vol. viii, p. 371; 1887, FOERSTE, Bull. Sci. Lab. Dennison Univ., vol. ii, p. 170.

Zoaria forming conical, hemispheric, discoid or irregular masses; at other times growing in thin expansions; usually free in the adult state, with a wrinkled epithecal covering upon the lower concave or flat side. Zoœcial tubes prismatic or cylindrical, thin-walled, partially separated from each other, occasionally completely isolated by smaller angular mesopores, best seen in young specimens and thin transverse sections, and perhaps always smaller and less readily distinguishable at the surface of mature or old examples. Acanthopores usually present, but in most cases neither numerous nor strong. Cystiphragms in all the zoœcial tubes. Diaphragms crowded in the mesopores.

Type: *P. grayæ* Nicholson and Ethridge.

This is one of the best characterized genera of paleozoic Bryozoa. The species moreover are most of them common fossils and widely distributed, so that the genus is also important in a geological sense. Most of the species are restricted to the Trenton rocks, and only one, *P. parmula* Foerste, of the Clinton of Ohio, is as yet known from strata above the top of the Lower Silurian.

Prasopora simulatrix *Ulrich.*

PLATE XVI, FIGS. 1-10.

Prasopora simulatrix Ulrich, 1886. Fourteenth Ann Rep. Geol. Nat. Hist. Surv. Minn., p, 85.

Zoarium discoid in the younger stages, becoming hemispheric or subconical with age; occasionally the central part of the upper surface is drawn out, and in a few instances has been observed even to divide into two branch-like lobes. The last conditions, as well as various other irregular developments, are to be considered as abnormal. Base more or less concave, usually with a central cicatrix of attachment beyond which it is covered with a concentrically striated and wrinkled epitheca. Upper surface celluliferous. Hight of zoarium varying from 5 mm. or less to 50 mm. or more; diameter from 10 to over 100 mm. Zoœcia with direct, subcircular apertures, thin walls, those of neighboring cells generally in contact except at the angles of junction, the latter being occupied by angular mesopores of variable though usually small size. In the youngest specimens the zoœcia are the roundest and the interspaces, occupied by the mesopores, the widest, while in the oldest the opposite conditions prevail. More or less conspicuous clusters of cells of larger size than the average occur at intervals of nearly 4 mm., measuring from center to center. Between these cells the mesopores are commonly more numerous than elsewhere, and in nearly all cases constitute aggregations of variable extent and substellate form. These aggregations are unusually large and conspicuous in the var. *orientalis* to be mentioned presently. In many cases, chiefly old examples, the mesopores between the zoœcia occupying the intermacular spaces might be overlooked, although, as shown by thin sections, they are really numerous even there. Diameter of an ordinary zoœcium about 0.25 mm., with an average of eleven in 3 mm. Those forming the clusters vary in size, generally, from 0.25 to 0.38 mm., but in the var. *orientalis* a few in each may attain a diameter of 0.48 mm. Acanthopores wanting.

Internal characters: These, as shown in over one hundred thin sections, are very constant in all the essential parts. In tangential sections the form of the zoœcial tubes varies from perfectly circular to polygonal, their walls in most cases being very thin, and the cavity of each intersected by the crescentic edges of one or more cystiphragms. The opening left by the cystiphragms is generally lateral and of bi-convex shape, occasionally it is subcentrally situated and oval, but more commonly two or more cystiphragms combine to give it a subtriangular form. An abnormality is sometimes met with in the confluence of two zoœcia (see lower right-hand corner of fig. 9). The zoœcia are in contact with each other only in part perhaps only at limited points, the interspaces left between them being occupied by the small mesopores. These vary somewhat in number, and more so in size, but are always decidedly angular. At intervals they are collected into substellate maculæ of greater or less extent, and in the immediate vicinity of these the zoœcia are of appreciably larger size than elsewhere. No evidence whatever of acanthopores has been detected.

In vertical sections the cystiphragms form continuous series on one or both sides of the tubes, according as they extended all around the circumference or embraced only a portion of same, while an equal number of straight diaphragms crosses the remaining portion of the tube. In the Kentucky, Tennessee, and Minnesota form of the species the tabulation of the tubes is more uniform and crowded than in the Canadian and New York variety, for which the name *orientalis* is proposed. In the former the cystiphragms average sixteen or seventeen in 2 mm., while in the latter the average does not exceed thirteen, and in some cases is not over ten in that space. In the mesopores the diaphragms are simple, and average about eighteen in 1 mm. for the typical form, and twelve for var. *orientalis*.

Variety ORIENTALIS, *n. var.*

PLATE XVI, FIGS. 1, 2, 6, 7.

Monticulipora (Diplotrypa) whiteavesi (part.) Nicholson, 1879. Pal. Tab. Corals, p. 316.

This subordinate name is proposed for the eastern variety of the species. It is distinguished from the typical form by the greater extent and distinctness of the substellate maculæ, the greater size attained by the zoœcia in the immediate vicinity of the maculæ and the less compact tabulation of the zoœcia and the mesopores.

This species may really be the one referred to by Vanuxem in 1842 (Geol. 3d Dist. N. Y. p. 46), when he speaks of "The Puffball favosite (Favosites lycopodites)" as being highly characteristic and in great numbers in the Trenton limestone of New York. He adds, "it is found also in the lower part of the Utica slate, where it ends," and that "it is equally abundant at Frankfort, Kentucky, where it received the name of *Trianisites cliffordi*."

The name *Favosites* or *Chætetes lycoperdon* (equivalent to Vanuxem's *Favosites lycopodites*) is generally credited to Say, but no description of the form was ever published by him, and the first known of the so-called species under that name is found in vol. i, Pal. N. Y., 1847, in which Hall devotes nearly two plates to the illustration of its supposed variability. I might point out some of the now only too evident incongruities in the assemblage of forms so placed by that even then experienced observer, but it would be more than useless, since, if such a name has any claim whatever to stand, we must go back to Vanuxem's *lycopodites*, because it has priority not only of publication but also in the matter of illustration.

Professor H. A. Nicholson has given his views on the value of these equivalent names in his work on "The Genus Monticulipora," p. 8, 1881, and as my own conclusions on the points at issue agree thoroughly with his I cannot do better than quote his excellent statement of the facts: "My object in mentioning this in this place is twofold. On the one hand, there are few corals which have been more commonly quoted by American geologists and paleontologists than *Chætetes lycoperdon* Say, or *Chætetes lycopodites* Vanuxem; and it would therefore be very desirable to establish, if possible, the precise nature and characters of the form to be understood by this name, though I am not aware that this has ever been satisfactorily accomplished. On the other hand, I wish to record the opinion that the generally laudable desire of preserving an old name, where this is possible, may sometimes be carried too far, and that this is, in my view, an instance in point. No definition of *Chætetes lycopodites* Vanuxem, which can be regarded as in any sense a definition, was given by its original author, or has since been supplied by any subsequent observer, while it is certain that this name (or the equivalent *C. lycoperdon* Say) has been applied by different writers to wholly different forms."* "Nor, in the case of a genus like *Monticulipora,* where external form goes for so little, can Vanuxem's original *figure,* however good, be regarded as satisfactory proof as to the species upon which he really founded the name in question. Under these circumstances, therefore, I think as I think about such names as *Favosites fibrosa* Goldf., and various other similar titles, that it would be a real gain to science if there could be a general agreement that designations of this kind—published, in the first place, with wholly insufficient definitions, and subsequently employed by others in widely different senses—should be dropped altogether, and that no attempt should be made to revive them."

To show the inadequacy of Vanuxem's figure, which shows absolutely nothing beyond the tubular structure of a hemispheric bryozoan mass, I have drawn the accompanying illustrations of the internal structure of four *hemispheric* species, all of them from the Trenton and supplementing those figured on plates XVI and XVII.

*I should like to add here that it would not be difficult to show that since 1842 no less than one hundred distinguishable froms have been included under this indefinite general designation. E. O. U,

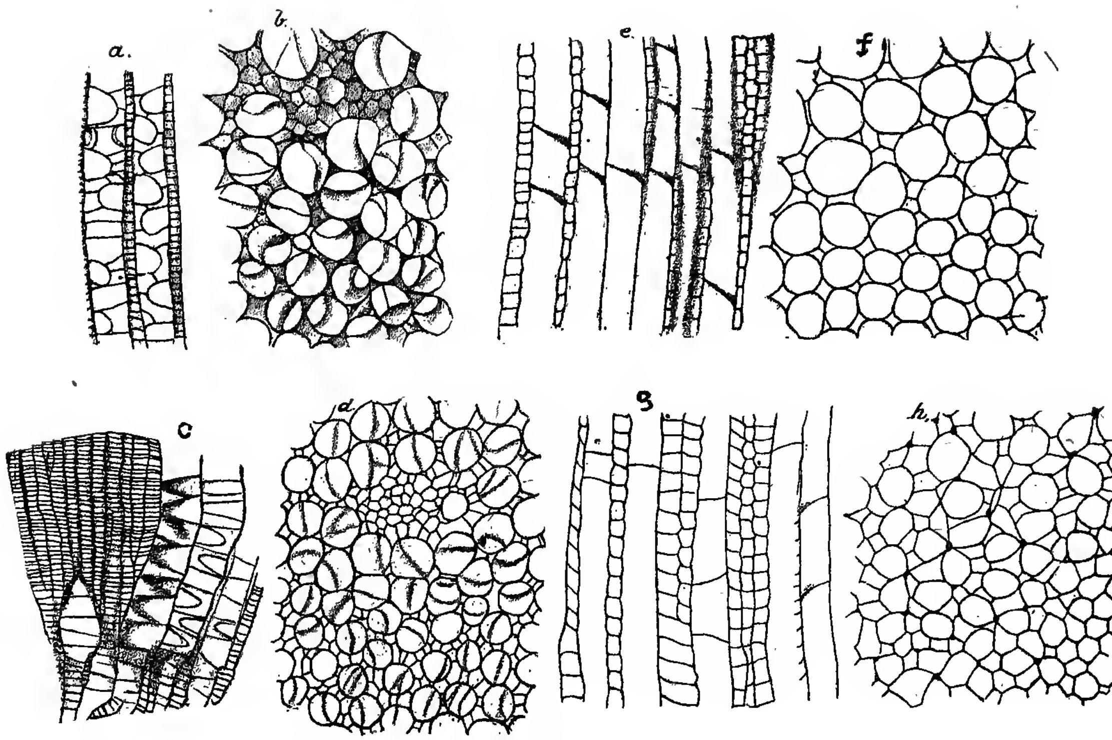


FIG. 15. *a* and *b*. vertical and transverse sections of *Prasopora selwyni* Nicholson, Trenton limestone, Ottawa, Canada; *c* and *d*, similar sections of *Prasopora oculata* Foord, Galena shales, near Cannon Falls, Minnesota; *e* and *f* similar sections of *Mesotrypa quebecensis* Ami, sp., Trenton limestone, Little Falls, N. Y.; *g* and *h*, similar sections of *Mesotrypa whiteavesi* Nicholson, sp., Trenton limestone, Ottawa, Can. All the figures are x18.

Indeed, there are at least ten hemispheric species, to any one of which the original of Vanuxem's figure might have belonged. Most of these are species of *Prasopora* and *Mesotrypa*, but I do not in the least doubt that Vanuxem, as well as all the other early workers in geology, would have included under one specific name, and perhaps did, also species of *Leptotrypa*, *Monotrypa*, and even *Crepipora*, having a similar mode of growth. In the absence of his illustrated specimen, and the utter impossibility of deciding permanently to which of these various forms it belonged, it seems to me not only desirable but necessary to drop the names *lycopodites* and *lycoperdon*, so far as their application to fossils of the types in question is concerned.

Formation and locality.—The typical form of the species is one of the most abundant and characteristic fossils of the shaly part of the Trenton group of central Kentucky. It occurs also at Nashville, Tennessee, and in the Galena limestone at Neenah and Oshkosh, Wisconsin, and Decorah, Iowa. In Minnesota it is abundant in the upper third of the Trenton shales at St. Paul, and rather rarely at other localities in the state. Also in the upper part of the Galena shales at Kenyon and other points in Goodhue county. The exact horizon of certain specimens in the state collection labeled Minneapolis, Lanesboro and Mantorville, is somewhat doubtful. The variety *orientalis* is common in the Trenton limestone at Ottawa, Peterboro, and other localities in Canada, and at Trenton Falls, New York.

Mus Reg. Nos. 4041, 5124, 5532, 5986-5988, 6786, 7570, 7571.

Prasopora contigua *Ulrich.*

PLATE XVI, FIGS. 24-26

Prasopora contigua Ulrich, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 87.

Zoarium hemispheric, base flat or slightly concave, usually less than 30 mm. in diameter. Zoœcia with very thin walls and polygonal apertures, ten or eleven of the average size in 3 mm. Clusters of zoœcia, some of them attaining a diameter of 0.37 mm., occur at intervals of a little less than 4 mm. Mesopores comparatively few, often difficult to detect at the surface.

Internal structure: Tangential sections show that the zoœcial walls are polygonal and very thin, with neighboring cells in contact, except at many of the angles of junction, these being occupied by one or two small mesopores. The latter often form very inconspicuous clusters at the center of the groups of large zoœcia, but in the intermediate spaces not over half of the angles of junction between the ordinary zoœcia are occupied by mesopores. A few very small acanthopores are developed. The opening left by the cystiphragms is generally of ovate form and more often eccentric than central in its position within the tube cavity.

Vertical sections are peculiar chiefly because they exhibit a marked decrease in the number of mesopores when compared with other species of the genus.

This form is closely related to *P. simulatrix*, and perhaps should be classed as a variety of that species. The distinguishing features are (1) the much smaller number of mesopores, (2) thinner walls, (3) the presence of small acanthopores, and (4) a somewhat greater crowding of the cystiphragms, these averaging over twenty in 2 mm. More specimens are necessary before the constancy, and, therefore, value, of these differences can be established fully. The same species, very slightly modified, occurs at Cincinnati, Ohio, about three hundred feet above the Ohio river bed.

Formation and locality.—The Minnesota specimens are believed to have been found either in the upper part of the Trenton shales or in the Galena shales, at localities in Goodhue and Dakota counties.

Mus. Reg. Nos. 5301, 5534, 5989.

Prasopora conoidea *Ulrich.*

PLATE XVI, FIGS. 11-15.

Prasopora conoidea Ulrich, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 87.

Zoarium generally depressed-conical, with the hight a little more than half the diameter; at other times subhemispherical; hight varying from 4 to 16 mm., the diameter from 8 to 20 mm. Under surface rather deeply concave, wrinkled concentrically, with a small central scar. Upper surface celluliferous and presenting, at intervals of about 3 mm., more or less prominent monticules, whose summits usually appear subsolid or minutely pitted; their slopes are occupied by zoœcia above the average in size. Zoœcial apertures subcircular, eleven or twelve of those of the ordinary size in 3 mm. Mesopores abundant, in most cases readily distinguishable at the surface with the aid of a good lens. Acanthopores small, inconspicuous.

Internal characters: These require no detailed description, being brought out sufficiently in figs. 14 and 15. Compared with those of *P. simulatrix* Ulrich, we find that the zoœcial walls are thinner, the mesopores rather more abundant, and that small acanthopores, one or more to each zoœcium, are present, these structures being absent in *P. simulatrix.* The tabulation of both sets of tubes is also more compact, the average number of diaphragms in the mesopores in 1 mm. being about thirty, and the cystiphragms in the zoœcial tubes over twenty-five in 2 mm. In the latter respect the species is nearer *P. contigua* Ulrich, from which it is distinguished by its smaller size, more conical form, tuberculated surface, and more numerous mesopores. More than five hundred specimens show that the subconical form, more or less developed monticules, the strongly concave base, and the small size of the zoarium are persistent characters, sufficing to distinguish the species almost at a glance from other forms of the genus.

Formation and locality.—Restricted to the upper third of the Trenton shales, occurring rather rarely at St. Paul, but more abundantly at several localities in Goodhue county. The best locality is at Oxford Mills, near Cannon Falls.

Mus. Reg. Nos. 3483, 7622, 8024, 8037.

PRASOPORA SELWYNI *Nicholson.*

PLATE XVI. FIGS. 16-17.

Monticulipora (*Diplotrypa*) *whiteavesii* (part.) NICHOLSON, 1879. Pal. Tab. Corals, p. 316.
Monticulipora (*Prasopora*) *selwynii* NICHOLSON, 1881. "The Genus Monticulipora," p. 206.

Zoarium discoid, subconical, or hemispheric, rarely more than 30 mm. high, and in most cases varying between 40 and 90 mm. in diameter. Base flat or gently concave, the epithecal plate striated or wrinkled concentrically. Surface characters of the Minnesota specimens obliterated through weathering, the only one still distinguishable being the substellate maculæ. Their specific characters, however, are clearly determinable by means of thin sections.

Tangential sections are not materially different from those of *P. simulatrix* Ulrich. As a rule the zoœcial walls are a little thinner, and the mesopores of larger size. But vertical sections, as may be seen by comparing figs. 1 to 5 with 16 on plate XVI, are quite different. The tabulation of the tubes is on the whole less compact, but the principal peculiarity is found in the cystiphragms, these appearing as series of semicircular lines, each distinct from the other, on one or both sides of the zoœcial tubes. In the latter case they are arranged alternately. About three cystiphragms occur on each side in 1 mm., while in the same distance six or seven diaphragms cross the space left by them. This is the usual arrangement of the cystiphragms, but in many of the tubes they also form loose connecting series very much as in *P. similatrix*, var. *orientalls* (see plate XVI, fig. 2).

This species is certainly distinct from *P. simulatrix*, the isolated condition of the cystiphragms being too striking a feature to be considered as less than specific. Foord's *P. affinis* and *P. oculata*, the first especially, are closer relatives, having likewise the cystiphragms isolated and not forming continuous series. The first, a smaller species, with no maculæ, and conical instead of semicircular cystiphragms, is known as yet only from Canada.* *P. oculata*, however, has been found in Minnesota, and is described on a succeeding page.

Formation and locality.—Dr. Nicholson's types of the species are from the Trenton limestone of Peterboro', Ontario. Foord says the species "is very abundant throughout the Trenton formation of Canada." Also that it has been found in the upper beds of the Chazy, at Nepean, near Ottawa. The Minnesota specimens were collected by the author in the upper part of the Galena shales near Cannon Falls. It is there associated with ***Monticulipora grandis*** Ulrich, another massive but more irregularly growing form, that was at first believed to be restricted to the top of the lower limestone.

Prasopora insularis, *n. sp.*

PLATE XVI, FIGS, 18-23.

Zoarium small, discoid, plano- or concavo-convex, commonly from 15 to 20 mm. in diameter and 5 or 6 mm. in hight. In a very large example these dimensions are respectively 28 and 12 mm., while in the smallest seen they are 1.5 and 0.5 mm. Under surface with a central scar, and beyond it delicate radiating lines, fine concentric striæ, and, at intervals indicating stages of growth, stronger wrinkles. Very often the zoaria are evidently made up of distinct superimposed layers, but these are not usually distinguishable internally. Upper or convex surface without monticules, but exhibiting, at intervals of about 4 mm., distinct clusters of large zoœcia. Generally, at the center of each of these clusters, the mesopores which are small and in nearly all cases just about numorous enough to isolate the zoœcia, are gathered into groups of varying size. Zoœcial apertures circular, those in the clusters attaining a diameter of 0.4 mm., while those of the smaller size in the inter-macular spaces average about 0.22 mm., with eleven or twelve in 3 mm.

*Since writing this a number of specimens of *P. affinis* were collected near Cannon Falls in the upper part of the Galena shales, associated with species of *Nematopora* and *Arthroclema armatum*.

Internal characters: The first peculiarity to be noticed in tangential sections is the relatively great abundance of the mesopores. In most specimens they form a complete ring around the zoœcia, and it is chiefly the large cells in the clusters that are occasionally in contact at limited points. The zoœcial walls are thin, and in one section have the peculiar tubular structure shown in fig. 21. The cystiphragms are more numerous and extend to a less distance from the walls than in any other American species. The opening left by them is of various shapes, generally subangular, and often removed from the walls. True acanthopores have not been detected.

In vertical sections the abundance of the mesopores, the narrowness of the cystiphragms, and the unusual crowding of the tabulation in both sets of tubes, are the distinctive features. In the mesopores the average number of diaphragms in 1 mm. is over twenty-five, while the cystiphragms may number as high as twenty in 1 mm., though the average is not likely to be over fifteen in that space.

Figures 18 and 19 represent one of two examples that may prove distinct. In tangential sections it differs in the greater size of the mesopores, and in the different appearance of the cystiphragms. In vertical sections the cystiphragms are less crowded and extend farther inward, while the mesopores here and there change into vesicles, a peculiarity that has not been observed in the usual form of the species. Provisionally the doubtful form may be distinguished as var. *filmorensis*.

This species is readily recognized by its small size and discoid shape. When studied by means of thin sections it cannot be confounded with any other known to me.

Formation and locality.—This is probably the commonest and most characteristic fossil of the Galena shales, having been found in greater or less abundance at nearly every locality in the state where that horizon is known to be exposed. The species also occurs in the Galena at the quarries near Neenah, Wisconsin, and at Decorah, Iowa. Var. *filmorensis* seems to have come from a lower horizon at Fountain and Preston, both in Fillmore county.

Mus. Reg. Nos. 310, 5991, 5992, 7569, 7601, 7611, 7628, 7637, 7644, 7666, 8057; var. *filmorensis*, 5990.

PRASOPORA OCULATA *Foord.*

FIG. 15, *c*, *d*, PAGE 248.

Prasopora oculata FOORD, 1883. Contri. Micro-Pal. Cambro-Sil. Rocks, Can., p. 11.

Zoarium a thin, discoidal expansion, 15 to 30 mm. in diameter, and from 1 to 3 mm. in thickness. Of the Minnesota examples none is thicker than 2 mm., and all are nearly 25 mm. in diameter. Under surface flat or gently concave, and marked with more or less strong wrinkles of growth, and sometimes with very fine radiating lines. Upper surface celluliferous, exhibiting subsolid maculæ (clusters of mesopores) at intervals of about 3 mm., each a mm. or more in diameter. Surrounding these the surface is depressed to a variable degree, and occupied by angular zoœcial apertures of comparatively large size and very few mesopores. The average diameter of these zoœcia is about 0.28 mm. On the rounded ridges between the depressions the zoœcial apertures are circular and smaller, averaging about 0.2 mm. in diameter; here they are also completely surrounded by a row of small mesopores.

Internal characters: The tangential section figured on page 248 shows in the upper half one of the maculæ with the large zoœcia surrounding it and occupying the depressed hexagonal surface spaces. Between these zoœcia the mesopores are very few, but farther out, in spaces representing the ridges (lower third of figure), the mesopores usually completely isolate the, here also smaller, zoœcia from each other. Acanthopores are wanting.

In vertical sections (fig. 15*c*) the maculæ appear as numerous, small, subequal, closely tabulated tubes. One or two similar mesopores occur between many of the zoœcia in the inter-macular spaces. In the zoœcial tubes the transverse partitions are quite different. The appearance of the cystiphragms depends upon the direction in which the section passes through them. When this is at right angles they appear (see the central tube of the three shown in the figure) as narrow loops projecting inward from the walls. Sometimes a complete diaphragm passes between each pair. A variety of appearances, some of them shown in the figure, result when the section passes through the cystiphragms at other than a right angle.

This species is readily distinguished from its associate, *P. insularis* Ulrich, as well as from all the other species of the genus known to me, by the division of the surface into subhexagonal depressed spaces. The zoarium is also unusually thin, while the internal structure is peculiar enough to be distinguished at once, even from its nearest allies, *P. affinis* Foord, and *P. selwyni* Nicholson. Still, I am not fully satisfied that the form is in all cases to be distinguished specifically from *P. affinis*, small specimens of which have recently been found associated with it.

Formation and locality.—Rather rare in the Galena shales at several localities in Goodhue county, Minnesota. The types of the species are from the equivalent Trenton limestone at Ottawa, Canada.

Mus. Reg. No. 7625.

PRASOPORA LENTICULARIS, *n. sp.*

PLATE XVII, FIGS. 22-25.

Zoarium small, lenticular, beginning its growth upon foreign bodies, as far as observed, about 12 mm. in diameter and 1 mm. thick. Zoœcial apertures regularly arranged, oval, twelve or thirteen in 3 mm., each of the smaller or average size 0.18 by 0.23 mm. In the clusters a few of the largest may attain a size of 0.35 by

0.28 mm. Zoœcial walls very thin, in contact at limited points, yet leaving comparatively large and easily distinguished interspaces, which, because the prevailing arrangement of the apertures is quincuncial, are commonly bounded by four concave sides. In most cases each of these spaces is occupied by a single mesopore, averaging 0.1 mm. in width and a little more in length. Mesopores but little if at all more numerous in the clusters than elsewhere. They may be however a little larger and less regular in shape. Acanthopores apparently wanting.

This species may be nearly related to *P. simulatrix* Ulrich, but it is not its young. This is shown best by thin sections, but the smaller size and more oval shape of the zoœcial apertures, the absence of maculæ, and the larger size and different shape of the interspaces, alone are sufficient in discriminating between them. Comparing internal characters these differences are emphasized, while another point is added in the greater separation of the diaphragms in the mesopores. Tangential sections are a little like those of *P. insularis*, var. *filmorensis*, but the zoœcia in that species are completely isolated, and the tabulation of both sets of tubes much more crowded. It seems to me that *Aspidopora parasitica* Ulrich, is more closely related, but differs sufficiently in its parasitic growth, more closely tabulated mesopores, and in possessing small acanthopores.

Formation and locality.—Rare in the upper third of the Trenton shales at St. Paul, Minnesota.

Genus ASPIDOPORA, Ulrich.

Aspidopora, ULRICH, 1882. Jour. Cin. Soc. Nat. Hist., vol. v, p. 155; 1890, Geol. Sur. Ill., vol. viii, p. 373.

Zoarium consisting of one, or two or more superimposed, thin expansions, each 1 mm. or less thick, rarely parasitic, generally free, with an epithecal covering on the concave lower side; typically composed, according to age, of from one to many subequal parts, each gently convex, with the zoœcia increasing in size from their margins to near their centers. Mesopores numerous, largest and best seen externally in the younger stages. Acanthopores usually present, always small. Diaphragms horizontal and closely set in the mesopores, usually wanting in the zoœcial tubes, but one or more cystiphragms occur in most of the latter.

Type: *A. areolata* Ulrich, Utica horizon, Cincinnati group.

This genus is so closely related to *Prasopora*, Nich. and Ethr., jr., that for some time I have considered the propriety of dropping the name in favor of theirs. But, as I could not arrive at a wholly satisfactory conclusion, it seemed best to retain the genus till we can learn more of the developmental history of this section of the *Monticuliporidæ*.

Taking *Aspidopora* in the sense above described, there is only one character (the other peculiarities being dependent upon it) that will distinguish it from *Prasopora*, namely, the thinness of the zoarial expansion and the consequent brevity of the zoœcial tubes. That this is the mature condition of the zoaria is proved by finding hundreds of examples of some of the species, not one of which exceeds 1 mm. in thickness, though many of them may be over 25 mm. in diameter. Some may consist (see plate XVII, fig 17) of several layers in contact at limited points but really quite distinct from each other, and thus showing that, beyond the development of the individual layers, the method of growth is not the same as in *Prasopora*. In that genus the tubes, though perhaps presenting many immature and mature regions or layers, are continuous throught the zoarium, even if it be over 50 mm. in thickness. The tabulation of the two sets of tubes is essentially the same in the two genera, excepting that in *Aspidopora* it is altogether as in the immature regions of a *Prasopora*.* Perhaps some significance is to be attached also to the fact that only a few cystiphragms and no straight diaphragms occur in the zoœcial tubes.

Seven species are referred to *Aspidopora* as now defined. The next described, *A. parasitica*, is the oldest, and occurs in the lower and middle thirds of the Trenton shales. This species is also one of the earliest known phases of the type of structure that at this time was evidently being rapidly differentiated into true *Prasopora* and *Mesotrypa*. Before we can fully understand the relations of these groups of species to each other it is necessary to discover the more primitive forms that are to be expected in the Chazy. The second species, *A. elegantula*, occurs in the Galena shales, and the five remaining, *A. areolata* Ulrich, *A. newberryi* Nicholson, sp., *A. calycula* (James) Nich., sp., *A. eccentrica* James, sp., and an undescribed species, in the lower two hundred feet of strata at Cincinnati, Ohio.

Aspidopora parasitica *Ulrich.*

PLATE XVII, FIGS. 26-32.

Aspidopora parasitica (part.) Ulrich, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 90.

Zoarium parasitically attached to shells, *Streptelasma profundum* Conrad, and other foreign bodies, upon which it forms very thin, subcircular or irregular patches, 10 to 20 mm. in diameter, and 0.5 mm. or less in thickness. Zoœcial walls very thin, apertures oval or circular, arranged in regular curved series around groups of cells distinctly larger than the average; eleven or twelve of the latter in

*In previous publications on this genus (*loc. cit.*) I did not mention the presence of cystiphragms because these structures seemed to be wanting in the type species. My present opinion is that the supposed diaphragms figured by me for *A. areolata* (*op. cit.*, vol. vi, p. 164), are really cystiphragms, in part incorrectly drawn.

3 mm. Of these the average diameter is 0.2 mm. or a fraction more, but that of the largest in the clusters is commonly about 0.3 mm., though of a few it may by 0.35 mm. Mesopores numerous, readily distinguishable even at the surface, not surrounding the zoœcia entirely. Acanthopores very small and inconspicuous.

Internal characters: These are faithfully and amply illustrated on plate XVII rendering a description unnecessary.

In my original description of the species I included another which is now separated as *Mesotrypa* (?) *spinosa.* While I still regard them as related forms, the result of a study of larger and better collections is to show that the latter is more intimately connected with *Mesotrypa infida* than with the form to which I propose to restrict the use of the name *A. parasitica.* I found no difficulty in distinguishing specimens of the two species after discovering that they were really distinct. In the *parasitica* the thickness of the zoarium is constantly 0.5 mm. or less, the acanthopores very inconspicuous, and the mesopores readily determinable under a good lens. In the *spinosa,* on the contrary, the zoarium may attain a thickness of over 2 mm., the mesopores are scarcely distinguishable at the surface, and the acanthopores strong. Among associated parasitic species there is another that the beginner may find it troublesome to separate. This is the *Atactoporella insueta,* really a very different species, with more numerous acanthopores and less regularly distributed zoœcial apertures.

Formation and locality.—Rather rare in the lower and middle thirds of the Trenton shales at Minneapolis, St. Paul and Fountain, Minnesota.

Mus. Reg. Nos. 5994, 5995.

ASPIDOPORA ELEGANTULA, *n. sp.*

PLATE XVII, FIGS. 13-21.

Zoarium a thin, concavo-convex expansion, 25 to 33 mm. in diameter, and 0.5 mm. or less in thickness; sometimes consisting of two or more of such layers grown loosely over each other. Under surface concave, with a concentrically and radially marked epithecal membrane. Upper or convex surface celluliferous. Zoœcial apertures ovate, their walls thin, in contact only at limited points, the interspaces distinctly occupied by mesopores, all the parts nicely arranged around clusters of large cells. The latter are 3 or 4 mm. apart, and in most cases slightly elevated. Average size of ordinary zoœcial apertures about 0.18 mm, by 0.25 mm., with eleven or twelve in 3 mm.; size of the largest in the clusters rarely exceeding 0.28 mm. by 0.37 mm. Acanthopores wanting.

Internal characters: These are sufficiently illustrated on plate XVII, but it is well to state that a few tubes in both vertical and tangential sections may show a single cystiphragm at the bottom. Diaphragms are wanting, as are acanthopores also.

This beautiful bryozoan is a true *Aspidopora*, and is rather closely related to *A. newberryi* Nicholson, sp., the only reliable or constant difference between them being in the number of cystiphragms. In the present species these structures are so few that they may appear to be wanting entirely, but in Nicholson's species they occur in every zoœcial tube, numbering in each, according to age, from one to ten. Several discoidal forms are to be found in the same beds with *A. elegantula*, but none of them are sufficiently like it to render confusion probable.

Formation and locality.—Rather rare in the Galena shales at St. Paul, and near Kenyon, Goodhue county, Minnesota.

Mus. Reg. No. 8126.

Genus MESOTRYPA, n. gen.

Diplotrypa (part.) NICHOLSON, 1879, Pal. Tab. Cor., p. 312, and 1881, The Gen. Monticulipora, pp. 101 and 155.

Zoaria hemispheric, conical, or discoidal, generally free, with the lower surface covered by an epitheca. Zoœcial tubes prismatic or cylindrical, more or less separated from each other by angular mesopores; internally with oblique and sometimes funnel-shaped diaphragms, that often simulate and probably are to be regarded as peculiarly modified cystiphragms. Mesopores becoming smaller with age, intersected by numerous diaphragms. Acanthopores generally present, sometimes of large size.

Type: *Diplotrypa infida* Ulrich.

This genus is established for a natural group of species heretofore referred, erroneously, I believe, to *Diplotrypa**. These species are *D. regularis* Foord, *D. quebecencis* Ami, *D. whiteavesi* Nicholson, *D. patella* Ulrich, the type *D. infida*, and three new species, *M. discoidea*, *M. rotunda*, and *M.* (?) *spinosa*. To these might be added the Niagara *D. milleri* Ulrich, but as the position of that species is somewhat in doubt, it had best be left as originally placed till an opportunity offers to rework the type specimens.

The affinities of the proposed genus are not with *Diplotrypa* but with *Prasopora*. Indeed, for some time I considered the propriety of referring the group to *Prasopora*, yet after mature reflection the erection of a new genus was decided upon as serving the purposes of classification better than would have been done by extending the limits of that genus.

*See part ii, Contri. Micro-Pal. Cambro-Sil. Rocks, Can., p. 32, 1890.

MESOTRYPA INFIDA *Ulrich.*

PLATE XVII, FIGS. 1-8.

Diplotrypa infida ULRICH, 1886, Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 88.

Zoarium discoid or subhemispheric, with the base flat or concave and partly covered with a concentrically wrinkled epitheca ; or it may be parasitic and conform with the shape of the body grown upon ; hight or thickness from 2 to 7 mm., diameter from 12 to 20 mm. Zoœcial apertures varying from polygonal to subcircular, the shape depending upon the number and size of the mesopores. In some specimens the latter are almost certain to be overlooked, the zoœcia being angular and seemingly in perfect contiguity (pl. XVII, fig. 8). In others they are large enough to constitute an obvious external feature (fig. 7). The latter condition is to be regarded as less mature than the former, since in it the acanthopores are scarcely distinguishable, while they are readily made out where the mesopores are smallest. At intervals of 3 or 4 mm. there are clusters of large zoœcia varying in diameter from the smaller or ordinary sizes of 0.2 to 0.24 mm. to 0.4 or 0.45 mm. An average of eleven of the ordinary size in 3 mm.

Internal structure: In vertical sections the tubes are everywhere perpendicular to the basal membrance. Their walls are a little thicker than usual in species of the genus. In the lower part of the zoarium the mesopores with their numerous diaphragms are very conspicuous. In following them upward they seem to be reduced in diameter, permitting the zoœcial tubes to come in contact with each other. These zones may be repeated several times. Diaphragms are numerous though not regularly distributed in the zoœcial tubes. The appearances presented by them are exceedingly variable. Some appear to be horizontal and straight or slightly bowed down in the middle (figs. 4 and 6), others are obliquely curved and perhaps overlapping (fig. 3), while still others are funnel-shaped (fig. 5). This variability however is not a structural peculiarity, but is due to the varying angles at which the diaphragms are cut by the section.

Tangential sections vary according to the depth from the surface at which they divide the zoarium. In the immature region (fig. 2) we have rounded zoœcia, almost completely surrounded by mesopores, and small acanthopores. In the mature region (fig. 1) the mesopores are much smaller, the zoœcia somewhat larger and subangular, and the acanthopores larger. In most of the zoœcial cavities the oblique and somewhat funnel-shaped diaphragms are represented by curved lines, often closely simulating the appearances of ordinary cystiphragms.

The mesopores are less numerous, and the tabulation of both sets of tubes more crowded than in *M. whiteavesi* Nicholson, sp. In *M. regularis* Foord, sp., the diaphragms are few in the zoœcial tubes. This is likewise true of *M. quebecensis* Ami, sp., in which acanthopores seem to be wanting entirely.

Formation and locality.—In the middle third of the Trenton shales at Minneapolis, St. Paul and localities in Goodhue and Fillmore counties, Minnesota.

Mus. Reg. No. 5993.

Mesotrypa (?) spinosa, *n. sp.*

PLATE XVII, FIGS. 9-12.

Aspidopora parasitica (part.) Ulrich, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 90.

Zoarium parasitic, 0.5 to 6.0 mm. thick. Zoœcia small, circular, neatly arranged about the clusters, twelve or thirteen of the ordinary size in 3 mm. Interspaces or walls rather thick, but the abundant mesopores shown in thin sections are rarely, if ever, to be made out at the surface. This may be due in part to the large size and prominence of the acanthopores. Internally, with crowded horizontal diaphragms in the mesopores and mostly oblique curved partitions in the zoœcial tubes. Sometimes a few at the bottom of the tubes are precisely like ordinary cystiphragms (fig. 12).

This form seems to hold an intermediate position between *M. infida* and *Aspidopora parasitica*, differing from the first in having smaller zoœcia, thicker walls and stronger acanthopores, and from the second in the greater thickness of the zoarium, much stronger acanthopores, different tabulation of the zoœcial tubes, and in but rarely showing the mesopores at the surface, these being, so far as observed, always distinctly visible at the surface of *A. parasitica*. *Atactoporella insueta*, another associated parasitic species, has larger and less regularly distributed zoœcia, with smaller and more numerous acanthopores.

Formation and locality.—Perhaps the commonest of the parasitic Bryozoa occurring in the middle third of the Trenton shales at St. Paul, Minneapolis and other localities in Minnesota.

Mus. Reg. No. 8127.

Mesotrypa quebecensis *Ami, sp.*

FIG. 15, *e* and *f*, PAGE 248.

Diplotrypa quebecensis Ami, 1892. Canadian Record of Science, p. 101.

Zoarium discoid or subhemispheric, base gently concave, hight 4 to 20 mm., diameter 12 to 45 mm. At Decorah, Iowa, the specimens are generally about 25 mm. in diameter, and 6 or 7 mm. thick. The same is true of the Kentucky examples, but in New York and Canada they are usually nearly again as large.

Mr. Ami's original type is probably a young specimen, being only about 12 mm. in diameter. Zoœcial apertures rounded, the largest of those in the clusters attaining a diameter of 0.4 to 0.45 mm., but those occupying the spaces between the clusters average about 0.24 mm., with eleven or twelve in 3 mm. Walls thin. Mesopores of variable size, not isolating the zoœcia, in most cases readily distinguishable at the surface; internally with diaphragms averaging about ten in 1 mm. Zoœcial tubes intersected by a few oblique curved diaphragms. These are developed chiefly in zones, 3 or 4 mm. apart, in which several occur approximately on the same level in all the tubes. In even these zones the diaphragms are separated but rarely by intervals less than 0.5 mm., while between the zones they may be wanting for a distance of 4 mm., though commonly occurring there at intervals of about 2 mm. Not a sign of acanthopores has been detected on the surface nor in thin sections.

This species is closely related to *M. regularis* Foord, sp., differing therefrom chiefly in wanting acanthopores. The same and other differences will be noticed when thin sections of it are compared with similar sections of *M. infida*, *M. whiteavesi* and *M. patella*, in all of which the zoarium has very nearly the same shape. Young examples are also very much like *Prasopora insularis* and *P. lenticularis*. Indeed, it is a matter of no small difficulty to identify with certainty any of the host of discoidal Bryozoa that are already known from Lower Silurian deposits without the aid of intelligently prepared thin sections.

Formation and locality.—Rather rare in the Galena Shales at Decorah, Iowa, in shales of the Trenton group at Burgin and Danville, Kentucky, and in the Trenton limestone at Trenton Falls, New York. Mr. Ami's type is from rocks supposed to be equivalent at Quebec, Canada.

Mus. Reg. No. 8128.

Mesotrypa discoidea. *n. sp.*

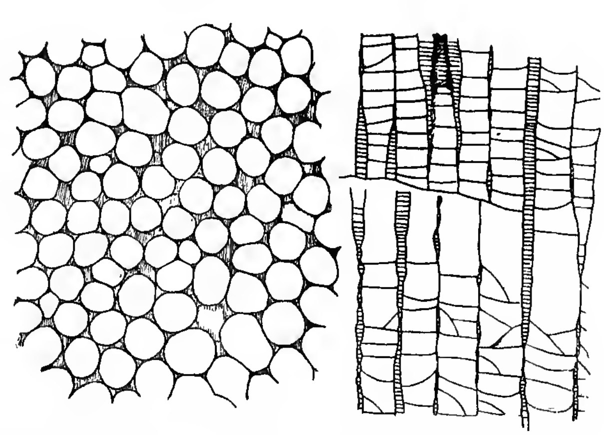


Fig. 16. *Mesotrypa discoidea* Ulrich, upper beds of the Galena shales, Goodhue county, Minnesota. Collection of E. O. Ulrich. Tangential and vertical sections, x 18, the latter consisting in part of two distinct layers.

Zoarium discoid, base flattened, upper surface gently convex; diameter, so far as observed, less than 20 mm.; hight, sometimes divisible into two subequal layers, 4 mm. or less. Upper surface with inconspicuous clusters of zoœcia a little larger than the average. Zoœcial apertures rounded, rather regularly arranged, about eleven in 3 mm. Mesopores numerous, rather small, occupying merely the triangular or quadrangular interspaces left between the adjoining rounded zoœcial walls. The latter are very thin. As usual with species of this and related genera the mesopores are more abundant (in this case completely isolating the zoœcia) in the basal or primitive part of the zoarium than in the fully matured superficial portion. Acanthopores apparently absent.

In vertical sections the chief peculiarity of the species is found in the tabulation of the tubes. In both sets of tubes, namely, diaphragms are present in unusually large numbers, there being a few more or less than thirty-five in 1 mm. in the mesopores, while in the zoœcial tubes the average is eight or nine in the same distance. In the latter the diaphragms, especially in the lower part, are frequently curved or oblique, as shown in the figure, but some of the tubes have practically horizontal diaphragms throughout. The mesopores are quite abundant at the curved basal part of the zoœcial tubes, becoming, however, very much less so soon after these assume an erect position. Many of the zoœcial walls may appear as completely in contact, but the rule is that at intervals, at any rate, they separate, producing the periodic tabulated swellings shown in the figure.

This species, having no acanthopores, belongs near *M. quebecensis* Ami, sp., from which it differs strongly in vertical sections, the diaphragms being much fewer in that species. *M. rotunda*, also without acanthopores, has more numerous and comparatively loosely tabulated mesopores.

Formation and locality.—Rare in the uppper part of the Galena shales (Anastrophia beds) at localities in Goodhue county, Minnesota.

MESOTRYPA (?) ROTUNDA, *n. sp.*

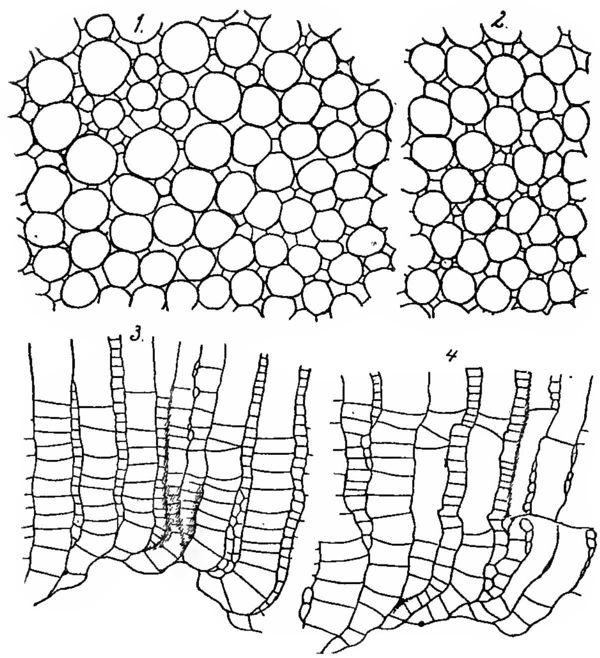


FIG. 17. *Mesotrypa rotunda* Ulrich, upper beds of the Galena shales, Hader, Goodhue county, Minnesota. Collection of E. O. Ulrich. 1, tangential section showing arrangement of cells about one of the clusters. The latter embraces several young zoœcia. 2, another portion of same section, with half of a cluster shown above. 3, vertical section passing through a cluster like the one represented in 1, and showing at center of figure several mesopores that have enlarged and assumed the tabulation of zoœcial tubes. 4, another portion of same section showing a partial break in the continuity of the tubes, and consequent irregularities in their tabulation. All x 18.

Zoarium a small hemispheric mass, 10 mm. in diameter, 6 mm. high, and 4 mm. thick at the middle, the under surface being strongly concave and wrinkled concentrically. Upper surface without monticules, but exhibiting fairly distinct clusters of large cells, rendered in many cases more so by aggregations of mesopores. Zoœcial apertures rounded, about eleven of the average size in 3 mm. Mesopores abundant, but seeming never to separate the zoœcia completely. Acanthopores wanting.

Internal structure as shown in the accompanying figures.

This form is distinguished from the other species of the genus in having all the diaphragms essentially horizontal. This fact casts some doubt upon the propriety of placing the species under *Mesotrypa*, and the uncertainty of the reference is emphasized by undoubted relations with species now classed as *Diplotrypa* (e. g. *D. milleri* Ulrich, and *D.? dubia* Ulrich), having a decided leaning toward *Callopora*.

Formation and locality.—Lower beds of the Galena limestone at Hader, Goodhue county, Minnesota.

Family BATOSTOMELLIDÆ, Ulrich.

Genus BYTHOPORA, Miller and Dyer.

Bythopora, MILLER and DYER, 1878, Contri. to Pal., pt, ii, p. 6; ULRICH, 1890, Geol. Surv. Ill., vol. viii, p. 376.

Zoaria consisting of very slender branches. Zoœcial apertures very small, oblique, lanceolate, narrowing above. Interspaces variable, generally thick, often channeled. Mesopores and diaphragms very few or wanting. Acanthopores usually present, never numerous, rarely more than one to each zoœcium.

Type: *B. fruticosa* Miller and Dyer. Cincinnati group.

The two species found in Minnesota are very similar to the typical species, and, although the latter is not as fully known as we would desire, there can be no reasonable doubt that the three forms are thoroughly congeneric. At least five other species occur in the rocks about Cincinnati, Ohio, but only two of these have been described, both by Nicholson, one as *Chætetes delicatulus*, the other as *Ptilodictya ? arctipora.* Still another form was described by me as *B. striata* from the upper beds of the Hudson River group at Stony Mountain, Manitoba, and Middletown, Ohio.

BYTHOPORA HERRICKI *Ulrich.*

PLATE XXVI, FIGS. 1-6.

Bythopora herricki ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 99.

Zoarium ramose, 20 to 40 mm. high, consisting of slender cylindrical branches, 0.8 to 2.0 mm. in diameter, dividing dichotomously at intervals of from 8 to 12 mm. Zoœcial apertures small, very oblique, narrow, rounded behind, drawn out in front; when perfect with a minutely granulose rim, highest posteriorly. Interspaces depressed, wider than the apertures. In the worn condition in which the species is often found, the ramulets appear to be made of thick-walled tubes with oblique apertures. The arrangement of the apertures is in more or less irregular, longitudinal and diagonal rows, with four in 1 mm. in the latter. Acanthopores small, few, but rarely preserved at the surface. True mesopores wanting.

Internal characters: A number of thin sections were prepared, but in all the finer details of structure are more or less completely destroyed by crystallization. The sections figured were prepared from an unusually old example. I have endeavored to represent the characters shown in these as faithfully as possible, and as I cannot add anything of importance not shown, it is unnecessary to attempt a description of them.

The species is closely related to *B. arctipora* Nicholson, sp., of the Cincinnati rocks, but the zoœcial apertures are narrower and more produced anteriorly than in that species.

Formation and locality.—Fragments of this species are common in the middle third of the Trenton shales at St. Paul and Minneapolis, Minnesota. Good specimens, however, are rare.

Mus. Reg. Nos. 6012, 6013.

BYTHOPORA ALCICORNIS, *n. sp.*

PLATE XXVI, FIGS. 7-9.

In this species the zoarium divides at shorter intervals than in any other of the genus known, the distance between the branches varying between the extremes of 1.5 to 6.0 mm. Compared with *B. herricki*, we find that the average size of the branches is a little less, that they bifurcate at shorter intervals, that the zoœcial apertures are arranged less regularly and on the whole less compactly, the direction of the rows being interrupted and changed by meeting with spots, 2 or 3 mm. apart, in which the interspaces between the apertures are much wider than elsewhere. These sub-solid spots distinguish the species from all the others as well, excepting an undescribed larger form occurring in the upper beds of the Hudson River group at Waynesville, Ohio, in which they are of greater extent and constitute a very obvious superficial character.

Formation and locality.—Upper third of the Trenton shales, associated with *Phylloporina corticosa* and *Prasopora conoidea*, near Cannon Falls, Minnesota.

Genus ERIDOTRYPA, n. gen.

Batostomella (part.) ULRICH, 1890. Ill. Geol. Sur., vol. viii, pp. 375, 432.

Zoaria ramose, branches slender. Zoœcia more or less oblique, with thick walls, the tubes intersected by diaphragms only. The latter may be wanting in the axial region, are in most cases absent for a short distance within the apertural edge, but always present and closest together in the turn from the axial into the narrow peripheral region. Mesopores with close-set diaphragms, varying in number, sometimes abundant, at other times very few. Acanthopores small, never numerous, sometimes wanting.

Type: *Eridotrypa mutabilis*, n. sp.

This genus became necessary partly through the restriction of *Batostomella* to its Carboniferous types, and partly for the accommodation of a number of species that could not be disposed of satisfactorily under any of the existing genera.* The

*It is unfortunate that both Hall's recently proposed *Trematella* (Pal. N. Y., vol. vi, p. xiv, 1887) and my *Batostomella* (1882) should have been founded upon practically the same type of structure. In both cases species are included doubtfully that are now to go under *Eridotrypa*.

genus will include beside the following, probably two as yet undescribed species from the Trenton of Kentucky, *Batostomella simulatrix* Ulrich, a widely distributed species from the upper beds of the Hudson River group, *Trematopora echinata* Hall, from the Niagara group of Indiana, *T.? (Trematella ?) corticosa* Hall (see Pal. N. Y., vol. vi, p. 15, pl. X, figs. 1-10), from the Lower Helderberg of New York, and *Batostomella obliqua* Ulrich, from the Hamilton group of Michigan.

The systematic position of the genus, though in a measure doubtful, is probably intermediate between *Homotrypa* (compare *H. similis* Foord) of the *Monticuliporidæ*, and *Bythopora*, Miller and Dyer, of the *Batostomellidæ*. Because of the absence of cystiphragms it will be best to embrace the genus provisionally in the latter family.

ERIDOTRYPA MUTABILIS, *n. sp.*

PLATE XXVI. FIGS. 20-32.

Zoarium ramose, dividing at rather long but irregular intervals; branches 2 to 6 mm. in diameter, the younger examples slender and nearly cylindrical, the old ones more or less irregular. Considerably over half of the hundreds of specimens seen are from 3.5 to 4.5 mm. in diameter. Zoœcial apertures variable, the changes due chiefly to age, always oblique, the degree decreasing with age; walls thick, generally ridge-shaped and highest posteriorly, sloping gradually down into the apertures. In young examples—also in old ones on which a new layer of zoœcial tubes was formed—the apertures may be exceedingly oblique and drawn out anteriorly. With age they became gradually more direct. The arrangement of the apertures is always more or less irregular, some of the short rows having six, others seven, and occasionally eight in 2 mm. Small maculæ, either pitted or irregularly sculptured, commonly present in the older examples. In others the maculæ are represented by clusters of zoœcia which, though a little larger than the average, are distinguished from them chiefly by the greater thickness of the interspaces. The mesopores too are most variable. In some cases, but this is rare, they will appear to be wanting over large portions of the surface (see fig. 24); in others they may be twice as numerous as the zoœcia. As a rule, however, they are to be counted as few, appearing at the surface, except in rare instances, only as occasional shallow depressions between the zoœcial apertures. True acanthopores probably wanting, but small knots at the angles of junction may be noticed.

Internal characters: These are, luckily, fairly constant in all essential features, the principal variations observed being in the number of mesopores. Figs. 26 to 28 represent parts of sections prepared from an average example. Diaphragms occur all through the axial region at intervals, averaging about twice the diameter of a tube. As the tubes are about to open at the surface the diaphragms increase in number, and immediately thereafter the walls are greatly thickened, and mesopores developed. The latter were unusually numerous in the sections drawn in figs. 31 and 32.

Variety MINOR, *n. var.*

PLATE XXVI, FIGS. 20, 21, 29, 30.

This name may be attached to the small form represented by the figures cited. The surface magnified is generally very much as shown in fig. 21, the zoœcial walls being thinner than in typical *mutabilis.* But the principal peculiarities are to be found in the axial region, as shown in vertical sections. First, the central tubes are unusually large and their walls more wavy than in typical *mutabilis;* second, the tubes altogether seem to have been developed more regularly, and their width in the peripheral region somewhat less; and third, diaphragms are wanting throughout the greater part of the axial region. Under ordinary circumstances these differences would be considered as of specific value, but in this instance, knowing the extreme variability of the species, I cannot credit them with more than subordinate importance.

The smaller size of the branches, oblique zoœcial apertures, and the thicker walls or inter-apertural spaces, distinguish the species without much trouble from associated species of *Homotrypa* and *Callopora.* Despite its variability, I have always found it one of the easiest of the numerous Trenton species to identify off-hand.

Formation and locality.—Very common in the Galena shales at many localities in Goodhue, Dakota and Ramsey counties in Minnesota; also at Decorah, Iowa, and in the Galena at Neenah and Oshkosh, Wisconsin; in the shaly portion of the Trenton group at many points in central Kentucky; also at Nashville, Tennessee, and Ottawa, Canada. Specimens referred to the var. *minor* are to be found also in the upper third of the Trenton shales at St. Paul.

Mus. Reg. Nos. 5541, 6009, 7561, 7603, 7623-3, 8034, 8050, 8079.

ERIDOTRYPA EXIGUA, *n. sp.*,

PLATE XXVI, FIGS. 17-18.

Zoarium small, branches very slender, several hundred fragments varying in diameter from 0.6 to 1.0 mm.; bifurcations apparently remote. Some of the fragments are pointed at the lower end, indicating a free condition of the zoarium, or an articulation like that of *Escharopora.* The eastern form of the species is usually a little stronger than the average of the Minnesota types, the specimens seen from

Vermont and New York being mostly 1.0 mm. or a little more in diameter. Considering the small size of the branches, the zoœcia are large. Their apertures are oblique, but not excessively so, subequal, and arranged in both longitudinal and diagonal series, the former with eight in 3 mm., predominating in the small specimens, and the latter in the larger. At the lower end of each aperture the wall is usually raised into a spine-like prominence. In vertical sections the greater part of the branch is seen to consist of comparatively large and nearly or quite vertical tubes, intersected here and there by a diaphragm. The peripheral region is exceedingly short and abrupt.

The small size of the branches might be regarded as indicating *Bythopora* rather than *Eridotrypa*, but the comparatively large zoœcia and the internal characters, so far as known, point to the last genus with considerable certainty. Considered specifically, its branches are so much smaller than those of even the var. *minor* of the preceding species that there is really no likelihood of confusion here. Both *Bythopora herricki* and *B. alcicornis* have smaller zoœcial apertures and impressed, instead of ridge-shaped, interspaces.

Formation and locality.—A large number of fragments were picked from washings of upper Galena shales collected from a locality near Cannon Falls, Minnesota. The eastern form of the species occurs in the Trenton limestone at Trenton Falls, New York, and Chimney Point, Vermont.

Mus. Reg. No. 8129.

Family HETEROTRYPIDÆ, Ulrich.

Genus HETEROTRYPA, Nicholson.

Heterotrypa (part.) NICHOLSON, 1879, Pal. Tab. Corals, p. 291; NICHOLSON, 1881, Genus Monticulipora, pp. 101 and 103.

Heterotrypa, ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 155; ULRICH, 1882, *idem*, vol. vi, p. 83; FOORD, 1883, Contri. Micro-Pal. Cambro-Sil. Rocks, Can., p. 20; ULRICH, 1890, Geol. Surv. Ill., vol. viii, pp. 371 and 413.

Zoaria frondescent, subramose, or incrusting. Zoœcial tubes prismatic, sometimes subcylindrical. Apertures angular, subcircular, or slightly petaloid. Walls moderately thin. Mesopores varying in number, sometimes abundant, with illy-defined walls. Acanthopores small, usually numerous. Diaphragms well developed, generally horizontal; occasionally a few may be concave or recurved.

Type: *H. frondosa* d'Orbigny, sp., (*H. mammulata* Nicholson, not d'Orbigny).

This genus is not yet known to occur in the rocks of Minnesota, but the two species following are to be looked for in the southern part of the state, being rather common fossils in the Hudson River rocks of Illinois and Wisconsin.

For remarks on this genus see under *Dekayella*.

Heterotrypa prolifica *Ulrich.*

(Not Figured.)

Heterotrypa prolifica Ulrich, 1890. Geol. Surv. Ill., vol. viii, p. 413, pl. xxxvii, fig. 1–1*d*.

Original description: "Zoarium frondescent, or subramose with much flattened branches ranging in thickness from 4 to 12 mm., and at times attaining a hight of 10 cm. Low rounded tuberosities arranged in irregularly intersecting lines, and composed of cells a little larger than the average, commonly surrounding a cluster of mesopores, serve to break up the monotony of an otherwise smooth surface. Zoœcial tubes curving in the axial region, direct throughout the peripheral region, where their walls become considerably thickened. Zoœcial apertures subpolygonal, about eight in 2 mm., and 0.15 to 0.18 mm in diameter. Interspaces occupied by calcareous matter; where very wide by a few mesopores with illy-defined walls. Most of the mesopores are found in the clusters.

A few diaphragms in the axial region; in the transition period they become more numerous; in the cortical region they are close set, a tube diameter or less apart. In the outer portion of this region they are often concave, sometimes tending to the infundibular form. Mesopores more closely tabulated than the zoœcial tubes. Acanthopores a little more than one-third as numerous as the zoœcia; when not situated at the angles, generally inflecting the zoœcial cavity a little."

"This species approaches quite closely to *H. frondosa* d'Orb., having a somewhat similar growth; but in that species the zoœcia are more angular, the walls thinner, mesopores far more numerous, and the acanthopores rather more abundant."

Formation and locality.—A common form in the upper beds of the Hudson river group at many localities in Ohio and Indiana, also at Wilmington, Illinois, and Iron Ridge, Wisconsin.

Heterotrypa singularis *Ulrich.*

(Not Figured.)

Heterotrypa singularis Ulrich, 1890. Geol. Surv. Ill., vol. viii, p. 415, pl. xxxvii, figs. 3–3*e*.

Original description: "Zoarium subramose, at times attaining a thickness of 7 cm. Surface smooth or nearly so, with clusters of cell apertures a little larger than the average. Zoœcia about nine in 2 mm., angular and thin-walled in the axial, subcircular in the mature region. There are commonly two or more successions of immature and mature regions. Mesopores of variable size, very numerous, usually angular or subcircular. Diaphragms developed very irregularly, at times but few in the cortical region and wanting in the axial, at other times about two tube diameters apart in the axial and close-set in the peripheral region. They are commonly horizontal, often concave, sometimes infundibular and occasionally simulate cystiphragms if they are not of that nature. Acanthopores very numerous, inflecting the viscerial cavity so as to give it a petaloid appearance.

"The extremely large size of this species, the remarkable development of acanthopores and mesopores and irregular character of the diaphragms are its leading features. Some points of its structure leave me in doubt as to this being its rightful position, but for the present it seems best to place it with *Heterotrypa*."

Formation and locality.—Upper beds of the Hudson river group at Wilmington, Illinois, and Iron Ridge, Wisconsin.

Genus DEKAYELLA, Ulrich.

Dekayella, ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 155, and vol. vi, p. 90; 1890, Geol. Surv. Ill., vol. viii, p. 372.

Zoaria ramose, branches cylindrical or compressed. Zoœcia angular or rounded, the shape depending upon the number and disposition of the mesopores. Typically, the mesopores are more or less numerously distributed among the zoœcia, and aggregated into irregular clusters. In other cases they may be wanting, except in the clusters, while in some of the earliest forms they are so few as to be practically absent. Acanthopores of two sizes, the large ones, equivalent to those of *Dekayia*, commence in the axial region, the smaller ones more abundant and developed in the peripheral region only. Diaphragms horizontal, numerous.

Type: *D. obscura* Ulrich, Utica horizon of the Cincinnati group.

This genus includes, so far as known, the earliest types of the family *Heterotrypidæ*. In the Trenton or more strictly speaking, the Birdseye shales of Minnesota we have, besides species or varieties that are as typical of *Dekayella* as any occurring in the Cincinnati rocks, two forms that, in having very few mesopores, are more nearly like *Dekayia*, Edwards and Haime. Tangential sections of the one (*Dekayella prænuntia* var. *echinata*) very much resemble those of *Dekayia aspera* Ed. and H., yet when carefully examined, two sets of acanthopores—the one large, the other small—will be noticed. The abundant tabulation of the tubes is also indicative of *Dekayella*. The other form (*D. prænuntia* var. *simplex*) is, as the name implies, of a more simple and perhaps *the* primitive type, with the acanthopores much smaller and scarcely, if at all, separable into two sets.

The relations existing between *Dekayella*, *Dekayia* and *Heterotrypa* are so intimate that I have seriously considered the propriety of throwing them together as one genus. The chief reason for doing so is that with the great abundance of material —specific, varietal and individual—studied, an almost complete chain may be made out connecting one with the other. But, as I have had occasion to state more than once heretofore (*ante* pp. 115, 138, 216), this is not a sufficient reason for uniting two or more genera. The groups of species embraced in each are natural and in a great measure readily distinguished, and therefore must always be recognized in some manner. *Heterotrypa*, as restricted and used by me, includes only frondescent or palmate zoaria, with all the acanthopores small and approximately of one size; *Dekayia*, subcylindrical or flattened stems growing from a large base, with one set of acanthopores, mesopores very few or wanting, and few diaphragms in the tubes; and *Dekayella*, zoaria as in *Dekayia*, but with acanthopores of two sizes, mesopores more or less numerous, and abundantly tabulated tubes.

DEKAYELLA PRÆNUNTIA, *n. sp.;* and VARIETIES.

PLATE XXIII, FIGS. 32-47.

Compare *Heterotrypa ulrichii* NICHOLSON, 1881, "Genus Monticulipora," p. 131.

Typical form: Plate XXIII, fig. 43.

Zoarium ramose; branches subcylindrical, often compressed, dividing at irregular intervals, varying in diameter or width from 4 to 12 mm. Surface without monticules, but in well-preserved specimens minutely spinulose; clusters of large cells inconspicuous. Zoœcial apertures obscurely angular or rounded, enclosed by moderately thin walls, averaging about thirteen in 3 mm. Mesopores not very numerous, generally one to each zoœcium, rather irregularly distributed, often forming small clusters. Acanthopores small, about half the number of zoœcia.

Internal characters: In vertical sections the tubes are nearly vertical in the axial region, and here are crossed by diaphragms at intervals equalling two to four times their diameter. As the tubes bend outward an occasional acanthopore may be detected, while the intervals between the diaphragms become less, until in the fully matured peripheral region, in which the tubes are directed nearly at right angles to the surface, the average distance between them is about one-half their diameter. It is in the latter region that the mesopores are developed. These are distinguished by their smaller size and more crowded diaphragms. An obscurely beaded wall-structure, as shown in fig. 40, with overlapping diaphragms, is of common occurrence.

Tangential sections show that the zoœcia are mostly oval or rounded, their walls of variable thickness, and in part separated by intervening mesopores. The latter vary considerably both in number and size, with medium conditions about as in fig. 43. Acanthopores comparatively small, the principal set comparing in number with the zoœcia about as one is to four; small set very minute, not often preserved, at any rate, only rarely distinguishable in sections.

Mus. Reg. Nos. 6019, 6020, 8073, 8305.

Var. SIMPLEX, *n. var.*

PLATE XXIII, FIGS. 39-42.

In this form the mesopores are reduced numerically to a minimum. Indeed, they are not distinguishable externally, and only a very few are to be made out in tangential sections. The zoœcial apertures are polygonal and unusually regular in their arrangement. The walls, too, get to be stronger than in any other form of the genus, with perhaps one exception, while the acanthopores are, if not smaller, at any rate less noticeable in thin sections. From an external examination merely specimens of this species might be regarded, and with good reason, as belonging to the *Amplexoporidæ*. Certainly they would scarcely be suspected of being closely related to *Dekayella prænuntia*. But with the aid of thin sections, vertical ones especially, the true affinities of the form become obvious at once. Excepting that mesopores are practically wanting, there is little or no difference between vertical sections of the typical form of the species and var. *simplex*.

Mus. Reg. No. 8307.

Var. NÆVIGERA, *n. var.*

(Not Figured.)

This form differs from the preceding in having thinner zoœcial walls, and clusters of from five to thirty mesopores at the center of the usual groups of large zoœcia. In the var. *simplex* the zoarium consists generally of but few branches, but in the best examples of the present form they are numerous, strong and divide and inosculate freely, the whole forming a mass over 70 mm. in diameter.

Mus. Reg. Nos. 6018, 7669.

Var. ECHINATA, *n. var.*

PLATE XXIII. FIGS. 32-38.

This variety grows in large compressed branches, that seem never to inosculate. The clusters of large cells are moderately distinct, and frequently enclose small aggregations of mesopores. In having very few mesopores their structure agrees with the two varieties immediately preceding, but specimens are distinguished at once by the much greater size of the acanthopores, these being so large and prominent that they are easily seen by the unassisted eye. An average distance of 0.5 mm. separates them. Internally the walls vary in thickness, very commonly even in the same tangential section. Where they are thinnest the acanthopores are the most distinct, and it is chiefly in such parts that the small set is determinable. Aside from the latter the general appearance of tangential sections is decidedly like that of typical *Dekayia.*

Mus. Reg. Nos. 6016, 7657, 8022, 8098.

Var. MULTIPORA, *n. var.*

PLATE XXIII, FIGS. 44-47.

In this form the acanthopores are likewise very large and, as a rule, are to be seen with the naked eye on the surface of all well preserved specimens. Still there is, as may be seen by comparing figs. 44 and 45, considerable variation in their size, so that the identification of the variety depends chiefly upon the unusually numerous and large mesopores and the rounded shape of the zoœcia. In many cases, however, it is difficult to discriminate positively between the two sets of tubes, as these are shown in tangential sections. As a rule—perhaps the test is reliable at all times—the zoœcia never have any part of their walls convex upon the inner side. In vertical sections the mesopores are distinguished by having the diaphragms more crowded than they are in the zoœcial tubes. A radial arrangement of the cells about the acanthopores, as shown in fig. 45, is frequently noticeable. Both sets of acanthopores about equally numerous, but the smaller set is liable to be overlooked except when the walls are unusually thin.

Mus. Reg. Nos. 6021, 8306.

These species and varieties gave me more trouble than the whole genus *Homotrypa.* It seemed impossible to draw up a thoroughly satisfactory classification of the hundreds of Minnesota specimens of *Dekayella* studied. The separations made were generally recognizable, and some of them are based upon not only obvious, but upon what, as a rule, we may regard as important structural deviations. Extended investigation, however, seemed to show that in the present cases the peculiarities were too inconstant to deserve specific recognition. The var. *simplex* appears to be the best marked and most constant, and should, perhaps, have been called a good species, with var. *nævigera* under it. In that case the var. *echinata* also should be raised to the rank of a species. Variety *multipora*, however, though often very distinct (compare figs. 43 and 45, plate XXIII), is too intimately connected with the typical form of the species to admit of greater than varietal distinction.

My reasons for employing the adopted classification instead of the one just suggested, and which I really believe to be the best, are dominated by the fact that very similar variations are encountered in large collections of *D. ulrichi* Nicholson, sp., an exceedingly common species at Cincinnati, Ohio. This fact makes it, I think, not only desirable but necessary that these Minnesota lower Trenton forms be studied in connection with the various Cincinnati types of the genus. The most important point to be determined by such a study relates to the origin of the Cincinnati varieties mentioned as being similar to those here separated from *prænuntia*. Did the two sets of varieties have a separate origin, or did those above defined continue and develope into the supposed varieties of *D. ulrichi?* Although these questions, whose final solution would require months of careful labor, cannot now be answered definitely, sufficient data have accumulated incidentally to render it more than probable that a separate origin for the two sets is more nearly the truth of the matter. In other words, I believe that future investigation will prove that *D. ulrichi* was developed from some descendant of *D. prænuntia*, that the known varities of the latter became extinct before the close of the Trenton, and that in the Utica and Hudson river eras a new set of forms was developed from the *D. ulrichi* stock.*

Comparing *D. prænuntia* and *D. ulrichi* it is evident that the two species are closely related. In the tabulation of the zoœcial tubes, which is the least variable character in both, they are almost identical. The acanthopores furnish the only reliable point of difference, these structures being much more abundant in *D. ulrichi*.

Formation and locality.—The typical form and var. *multipora* are common in the middle third of the Trenton shales at St. Paul, Minneapolis, and localities in Goodhue and Fillmore counties. Var. *simplex* occurs in the lower and middle thirds at St. Paul and Minneapolis, while var. *nævigera* is as yet known only from Fillmore county, where it was found in the lower third of the shales. The var. *echinata* is rare in the upper part of the middle third of the Trenton shales at Minneapolis, but abundant in the lower part of the upper third at St. Paul, and near Fountain, Minnesota.

---

*It may be well to add that the var. *echinata* will probably prove to be the stock that produced *Heterotrypa* on the one side and true *Dekayia* on the other. Also that the small *Dekayella obscura* of the Cincinnati rocks may be a degenerate descendant of the var. *multipora*.

Genus DEKAYIA Edwards and Haime.

Dekayia, EDWARDS and HAIME, 1851, Mon. Pol. Foss. Terr. Pal., p. 277; NICHOLSON, 1879, Pal. Tab. Corals, p. 291; 1881, "Genus Monticulipora," p. 98; ULRICH, 1882, Jour. Cin. Soc. Nat. Hist. vol. v, p. 155, and vol. vi, p. 148; also 1890, Geol. Sur. Ill., vol. viii, pp. 371 and 415.

Zoaria irregularly ramose; branches subcylindrical or compressed, growing from a broad base. Zooecia polygonal, walls thin. Mesopores wanting or very few, when present restricted to the maculæ. Acanthopores originating in the outer part of the axial region, in most cases rather widely separated, often of large size; in other cases small, and in one instance equalling the zooecia in number. Diaphragms straight, in most cases remote, sometimes from one-half to one tube diameter distant in the peripheral region; wanting usually in the axial region. A thin calcareous pellicle often drawn over the zooecial apertures.

Type: *D. aspera* Ed. and H., Hudson River group.

For remarks see under *Dekayella*, p. 269. For more detailed observations and full descriptions of all the known Lower Silurian species, the reader is referred to my "American Paleozoic Bryozoa."* Beside the following, another as yet undescribed species of *Dekayia*, with fewer diaphragms, thinner walls and smaller acanthopores than *D. trentonensis*, occurs in Minnesota. It is rather rare, and so far known only from the Galena shales of Goodhue county.

DEKAYIA TRENTONENSIS *Ulrich.*

(Not Figured.)

Dekayia trentonensis ULRICH, 1882. Jour. Cin. Soc. Nat. Hist., vol. vi, p. 151.

Zoarium dendroid, branches compressed, dividing frequently and rather irregularly, 4 to 10 mm. in width. Entire hight of zoarium probably not exceeding 8 or 9 cm. Surface even, or with low rounded monticules, 2.5 mm. apart; the latter occupied by clusters of cells a little larger than those in the intermediate spaces, and occasionally have a few mesopores at their summits. Zooecia with comparatively thick walls, their apertures subangular, about fourteen in 3 mm. Acanthopores rather large, moderately prominent at the surface where six or seven are to be counted in 3 mm.

Internal characters: In the axial region of vertical sections the tubes have very thin and slightly flexuous walls, and are crossed by diaphragms from two to four times their diameter distant from each other. Bending into the peripheral region

*Jour. Cin. Soc. Nat. Hist., vol. vi, pp. 84 and 148-155.

with a gentle curve, the walls become thickened and the diaphragms more abundant, the intervals between the latter varying here from one-fourth to one tube-diameter, with seven in 1 mm. measuring from the surface of a fully developed example. Acanthopores originating in the outer part of the axial region, large and readily distinguished. Tangential sections with the walls rather thick and consisting of a central space, generally of light color, representing the original walls, and a dark ring-like deposit immediately about the zoœcial cavities. On the whole the structure and thickness of the walls is much as in *Dekayella prænuntia*, var. *simplex* (pl. XXIII, figs. 41 and 42). The acanthopores are isolated, occupying the points of junction between every three, four or five zoœcia. Their large size makes them very conspicuous in sections passing through deeper levels in which the walls are thinner than described.

In this species the diagnostic characters of *Dekayia* are not yet fully developed, the diaphragms being too numerous. A revision of the *Heterotrypidæ* would probably remove it to *Dekayella*. A more typical, but undescribed species, with fewer diaphragms and smaller acanthopores, is sometimes associated with *D. trentonensis* in the Galena shales. *Dekayella echinata*, which at first I confounded with the present species, has more numerous diaphragms, thinner walls, and a small set of acanthopores.

Formation and locality.—Rather rare in the upper third of the Trenton shales and in the overlying Galena shales at St. Paul, and near Cannon Falls, Minnesota. The original types are from the shaly portion of the Trenton at Burgin, Kentucky. The species is to be found also at Frankfort and other localities in that state, associated with *Prasopora simulatrix* Ulrich.

Family CALLOPORIDÆ, Ulrich.

Genus CALLOPORA, Hall.

Callopora, HALL, 1852, Pal. N. Y., vol. ii, p. 144, and 1887, Pal. N. Y., vol. vi, p. xv; NICHOLSON, 1874, Pal. Ontario, p. 61, and Geol. Mag., n. s., vol. i, p. 13; ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, pp. 154 and 251; also 1890, Geol. Sur. Ill., vol. viii, pp. 372 and 416; FOERSTE, 1887, Bull. Sci. Lab. Denn. Univ., vol. ii, p. 172.

?*Callopora*, DYBOWSKI, 1877. Die Chætetiden, p. 106.

Zoarium usually ramose, rarely subfrondescent, or pyriform; surface smooth or tuberculated. Zoœcial tubes with thin walls, varying according to the number of mesopores from circular or oval to polygonal in cross-section. Apertures closed in the perfect state by centrally perforated and often radially marked or ornamented plates, which are left behind as growth proceeds to form floors (diaphragms) of succeeding layers. Mesopores angular or rounded, more or less numerous, sometimes surrounding the zoœcia; closely tabulate. Zoœcial tubes attaining their full development slowly, with closely arranged diaphragms in the attenuate proximal ends, and fewer or no diaphragms in the middle part of their length. In the peripheral region these structures commonly increase again in number. Transverse sections show that in the axial region the tubes are of two sizes, the larger ones with six, seven, and most commonly eight sides, the smaller set four- or five-sided.

Type: *C. elegantula* Hall.

Thin sections of *Callopora*, vertical and transverse especially, exhibit a striking uniformity of structure, so that it is often difficult to discriminate between those of closely allied forms. Slight though generally recognizable peculiarities in the tabulation of the zoœcial tubes characterize the various species, but in a general way the distribution of the diaphragms is essentially the same in all. The axial or proximal end of the tubes always has diaphragms--sometimes only one or two (see plate XXII, fig. 15)—while these structures may be wanting in the rest of the tube, excepting one or two in the peripheral region. In other cases they will occur throughout, but in every instance they are less crowded in the central part of the tube than in its inner and outer parts (see plate XXII, fig. 36).

The twenty-five distinguishable forms now known to me of this, one of the best characterized and most easily recognized genera of the *Trepostomata*, are distributed through the various horizons intervening between the Birdseye and the top of the Upper Silurian, one or more species being characteristic of every recognized geological division embraced in the interval. Nearly all the species again are to be numbered among the common fossils, so that they may be said to be of the first importance to the stratigrapher. The described species are distributed as follows: In the Birdseye shales of Minnesota, *C. angularis*, *C. incontroversa.* and *C. undulata;* in the overlying Trenton and Galena shales, *C. dumalis*, *C. ampla*, *C. multitabulata*, *C. goodhuensis*, *C. crenulata*, *C. persimilis*, and *C. pulchella;* in the four horizons of the Cincinnati group going upward (1) *C. nodulosa* (Nicholson), *C. sigillaroidea* (Nich.), (2) *C. subplana* Ulrich, *C. dalei* (Edwards and Haime), *C. andrewsi* (Nich.), *C. ramosa* (d'Orb), (3) *C. subnodosa* Ulrich, (4) *C.* n. sp.; in the Clinton, *C. magnopora* Foerste; in the Niagara, *C. elegantula* Hall; and in the Lower Helderberg, *C. perelegans* Hall.

The affinities of *Callopora* doubtlessly are with the *Diplotrypidæ* and, but for the perforated closures of the zoœcia in *Callopora*, I would recommend placing the genus in that family. Aside from the closures, which, though they may really have existed, have not been noticed in any member of that family, and a difference in the method of growth, the zoaria of the one being ramose, of the other massive, *Callopora* and *Diplotrypa* (in the restricted sense recently employed by me*) are very similar. It

*Contri. to the Micro.-Pal. of the Cambro-Sil. Rocks of Canada, pt. ii, p. 32, 1889.

s true the zoœcial tubes of the latter are larger than is usual in *Callopora*, yet even in this respect the genera are brought together by *C. magnopora* Foerste, of the Clinton rocks of Ohio. In the remaining features the agreement is marked, both having more or less numerous mesopores and no acanthopores, while the tabulation of the tubes is essentially the same in the two genera, the proximal ends of the tubes being crossed by numerous diaphragms.

Batostoma, another genus of that family, also agrees closely with *Callopora*, the principal differences being the abundant presence of acanthopores, an irregularity in the tabulation and walls of the axial portion of the tubes, and the more ring-like character of the peripheral part of the zoœcial investment in *Batostoma*. These differences, however, are less obvious when we compare some of the earlier species referred to the two genera. Take, for instance, *B. decipiens* and *B. winchelli*, and *C. angularis*, of the Birdseye shales of Minnesota. In these species the mesopores are very few, the tabulation of the tubes alike in essential respects, and the axial region in transverse sections made up of large and small tubes. As differences we note that the *Batostomæ* have the walls more irregular in the axial region and thicker in the peripheral, and possess acanthopores, which are wanting in the *Callopora*.

Simple forms of the genus like *C. angularis* and *C. multitabulata* also remind one, especially in tangential sections, of *Monotrypella*, but it is more than doubtful that this resemblance indicates relationship. In any event I am now satisfied that I was in error in placing *C. multitabulata* with *Monotrypella*. This species differs from ordinary *Calloporæ* only in having fewer mesopores and more diaphragms, both points of slight importance. True *Monotrypella* is distinguished at once from *Callopora* by the subequal size of the tubes in the axial region of transverse sections.

CALLOPORA ANGULARIS, *n. sp.*

PLATE XXII, FIGS. 37-41.

Zoarium small or of medium size; branches 3 to 5 mm. in diameter. Zoœcial apertures angular, subequal, about niue and a half in 3 mm. Mesopores very few, occurring chiefly in small clusters. Walls rather thin, ridge-shaped.

Internal characters: Vertical sections show numerous diaphragms, whose distribution in the outer third of the section is shown in fig. 38 better than can be described. In the central third the proximal ends of the tubes increase very slowly in size. Here the diaphragms are also closer together than higher up in the tube. The axial region therefore appears as made up of two sets of tubes, one large with diaphragms averaging 0.25 mm. apart, the other small with diaphragms from 0.1 to

0.2 mm. apart. In tangential sections of fully matured examples (fig. 39) the zoœcia are decidedly angular, subequal, most of them in contact on all sides, the mesopores being small, very few, and sometimes restricted to certain spots where limited clusters may be found.

Both the mesopores and diaphragms are less numerous than in *C. multitabulata;* the angular shape of the zoœcial aperture will distinguish the species from other forms of the genus. I found it difficult to separate slightly abraded specimens of a small form of *Batostoma*, near *B. winchelli*, from those of the present species. When unworn the *Batostoma* has distinct acanthopores which are a sufficient mark, and when these have been removed by abrasion the student may succeed in separating them by measurement, the latter having eleven or twelve zoœcia where *C. angularis* has nine or ten.

Formation and locality.—Rather rare in the lower third of the Trenton shales at Minneapolis, Chatfield, and near Fountain, Minnesota.

Mus. Reg. Nos. 8088, 8097.

CALLOPORA INCONTROVERSA *Ulrich.*

PLATE XXII, FIGS. 33-36.

Callopora incontroversa ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 96.

Zoarium ramose; branches smooth, subcylindrical, 4.5 to 6 or 7 mm. in diameter, dividing dichotomously at intervals of 12 or more mm. Zoœcia with walls comparatively thin; apertures oval or subcircular, rarely polygonal; small, inconspicuous, and rather irregularly distributed clusters consisting of openings slightly larger than the average occasionally present; about ten apertures in 3 mm. Closures occasionally preserved; central perforation larger than usual, 0.07 to 0.08 mm. in diameter, enclosed by a thickened rim; apparently not radially marked. Mesopores numerous, small, scarcely gathered into clusters, usually occupying only the spaces left between the contiguous rounded walls of the zoœcia.

Internal characters: Tangential sections show that the zoœcia are broadly elliptical, rather thin-walled, and usually in contact with each other at as many points as their rounded form will admit. Interspaces occupied by the mesopores. At unequal intervals the latter may be more numerous and the zoœcia a little larger than usual, but these clusters are never conspicuous. In vertical sections the tubes form a gradual but rather short curve to the surface. In their tabulation and general appearance the proximal ends of the zoœcial tubes are so much like the true mesopores of the peripheral region that we cannot escape the conviction that their functions also were alike. From the point of origin till it has attained nearly its mature size, the tube is crossed by from ten to twenty or more closely and regularly arranged diaphragms. After this the diaphragms are much farther apart, and in many tubes may be wanting entirely until they enter the peripheral region when they once more come close together.

This species is distinguished from *C. undulata* by its slightly larger size, smooth surface, and slight differences in the tabulation of the tubes. In tangential sections the zoœcia of that species are less rounded. *C. goodhuensis* and *C. ampla* have fewer mesopores and more abundant diaphragms.

Formation and locality.—Rather rare in the lower third of the Trenton shales at Minneapolis, St. Paul and Preston, Minnesota.

Mus. Reg. No. 7653.

Callopora undulata *Ulrich.*

PLATE XXII, FIGS. 24-31.

Callopora undulata Ulrich, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 95.

Zoarium ramose, branches slender, averaging about 2.5 or 3.0 mm. in diameter, dividing dichotomously at intervals of 10 mm. or more. Surface with rather large, rounded monticules, that usually coalesce laterally, forming transverse ridges, or more or less complete annulations, five in ten mm. In some fragments and portions of others the monticules are separate, while in a few they are nearly obsolete. Zoœcia with moderately thin walls, subangular or ovate apertures, of nearly equal size over all portions of the surface; ten or eleven in 3 mm. Mesopores comparatively few, small, not readily distinguished externally, their mouths usually closed. Zoœcial covers not observed.

Internal characters: These are sufficiently shown in the illustrations, and, as they are also very similar to those of the preceding species, I shall only point out the differences. The walls in tangential sections are thicker than in *C. incontroversa*, the divisional line between adjoining zoœcia more distinct, and the mesopores less numerous.

C. angularis has a smooth surface, fewer mesopores, and more crowded diaphragms. *C. ampla* is distinguished in like manner, and *C. incontroversa*, externally, by its smooth surface and more rounded zoœcial apertures.

Formation and locality.—Not uncommon in the upper part of the middle third of the Trenton shales at Minneapolis and St. Paul, Minnesota.

Mus. Reg. No. 8113.

CALLOPORA MULTITABULATA *Ulrich.*

PLATE XXIII, FIGS. 11, 12, 16, 17, 24, 25, 26, 30, 31.

Monotrypella multitabulata ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 100.

Zoarium consisting of more or less irregularly divided, subcylindrical branches, their diameter averaging 7 or 8 but varying between the extremes of 3 and 10 mm. Surface generally with more or less strongly elevated, conical or rounded monticules, 2.5 mm. from center to center. The typical form of the species occurs in the Trenton of Kentucky and Tennessee, and in the upper third of the Trenton shales of Minnesota. In this monticules are always present, and they are occupied by zoœcia but little if at all larger than the average. Mesopores are exceedingly few at the surface, the zoœcia being angular, in contact with each other, their walls thin; apertures direct, with an average of eleven in 3 mm. Closures preserved in a few specimens, ornamented as shown in fig. 26. In the underlying middle third of the shales and in the overlying Galena shales there is a form, rare in the first, exceedingly common in the second, that varies in having the monticules lower and even quite inconspicuous, the zoœcia a little larger (ten in 3 mm), and the cells occupying the low monticules usually well distinguished by their size. Very frequently too a sprinkling of mesopores is detectable at the surface, as shown in fig. 31, but it is rare to find them as numerous as in fig. 30.

Internal characters: In tangential sections of the typical form the zoœcia are regularly polygonal, generally in contact with each other on all sides, and provided with moderately thickened walls, in which the original boundary line between the zoœcia is preserved as a sharp dark line. Mesopores are very few. Because of a lack of room no section of this form was illustrated, but a good idea of its appearance may be gathered from fig. 39 on plate XXII, and the upper third of fig. 17 on plate XXIII. In the Galena shales variety the appearance of tangential sections is generally as in the mentioned fig. 17.

In vertical sections (pl. XXIII, fig. 24) the peripheral region is comparatively wider than in other species of this type. Diaphragms exceedingly abundant throughout the tubes, the average distance between them in the axial region being about equal to their diameter; in the peripheral region twelve to sixteen occur in 1 mm. Here many of them may be slightly curved or joined to one another. An occasional mesopore is met with in these sections. These are very closely tabulated, the average number in 0.5 mm. being ten. Now and then one of the mesopores may widen and assume the characters of a true zoœcium.

In the central part of transverse sections the size of the tubes and the appearance in general is intermediate between figs. 20 and 21 of plate XXIII.

The diaphragms are more numerous in this species than in any other known to me. Very closely allied, however, are *C. angularis*, *C. ampla* and *C. goodhuensis*. The first is distinguished by its smaller size, smooth branches and somewhat less crowded diaphragms, especially in the mesopores; the second by its smooth branches, narrower peripheral region, slightly larger zoœcia and more numerous mesopores; the third is smaller, with smaller zoœcia and more abundant mesopores.

Formation and locality.—In Minnesota the species is rare in the middle third of the Trenton shales at Minneapolis, rather abundant in the upper third at St. Paul and in the vicinity of Cannon Falls, and exceedingly abundant in the Galena shales at many localities in Ramsey, Goodhue and Fillmore counties. Also a common fossil of the Trenton at several localities in central Kentucky, and near Nashville, Tennessee. The same species apparently occurs at Ottawa, Canada.

Mus. Reg. Nos. 3485, 7652.

Callopora ampla, *n. sp.*

PLATE XXIII, FIGS. 15, 18-20, 22, 23, 27, 28.

This form is very closely related to *C. multitabulata*, and doubtlessly belongs to the same line of development. Under the circumstances it will be sufficient to point out its peculiarities. The growth is less compact, the branches, though fully as large as in that species, being, as a rule, less frequently divided. Except in rare cases the surface is without monticules, and while there are clusters of zoœcia appreciably larger than the average they are never conspicuous except when elevated into monticules. The zoœcia are larger, with an average of nine in 3 mm., the apertures a little oblique, drawn out lengthwise and apparently more shallow, while the occasionally preserved closures seem to be without ornamentation. The form of the apertures may be oval or angular, the first when mesopores are comparatively abundant, the second when they are few and very small. In both cases, however, thin sections are generally required to demonstrate the existence of the latter. In most instances the mesopores are fewer than in fig. 18, and as a rule they occupy the angles of junction between the zoœcia where, when the surface is a little weathered, they often appear as acanthopore-like elevations.

Comparing internal characters we find that in *C. ampla* the tubes in the axial region are generally of larger size, and that they curve to the surface more slowly. The fully developed peripheral region is much narrower than in specimens of the same size of *C. multitabulata* (compare figs. 19 and 22 with 24 of plate XXIII), the superficial crowding of the diaphragms more sudden, and the intervals between them throughout the axial region a little greater. The last difference, however, does not apply when we compare the Galena shales varieties of the two species. These often agree so closely in every other respect as well that a rigid distinction between them is almost if not quite impossible. How else can we explain this fact than by assuming that the two forms gradually and by almost equal concessions approximated in structure?

Compared with other species *C. angularis* will be found to be smaller, with smaller and more equal-sided zoœcia and fewer mesopores. *C. goodhuensis* is smaller in every respect.

Formation and locality.—Rather abundant in the upper layers of the middle and in the lower part of the upper third of the Trenton shales at various localities in Ramsey, Goodhue and Fillmore counties, Minnesota. Common also at many localities in the state where the Galena shales are exposed, and in equivalent beds at Decorah, Iowa.

Mus. Reg. Nos. 7640, 7659, 8067.

CALLOPORA GOODHUENSIS, *n. sp.*

PLATE. XXIII, FIGS. 9, 10, 21, 29.

This also is closely related to *C. multitabulata.* As a rule the surface is without monticules, and they are never prominent, while the average size of the branches is less, the average diameter being between 4 and 5 mm. The zoœcia are smaller, especially at the center of transverse sections, their apertures subangular, rather oblique in young examples, nearly direct in those full-grown, with twelve or thirteen in 3 mm. Internal characters very similar, excepting that the peripheral region is comparatively narrower, being in this respect more like *C. ampla.*

Mesopores more numerous and more closely tabulated than in *C. angularis.* The zoœcial apertures, on the other hand, are more direct in that earlier species.

Formation and locality.—Common in the Galena shales at St. Paul and near Cannon Falls, Minnesota.

Mus. Reg. No. 8111.

CALLOPORA DUMALIS, *n. sp.*

PLATE XXIII, FIGS. 1-8.

Zoarium bushy, attaining a width of 50 mm. or more, consisting of numerous small inosculating branches, varying between 1 and 2.5 mm. in diameter, but with 1.5 mm. by far the most common size. In young stages the zoœcial apertures are more or less oblique and ovate, the mesopores rather numerous and some of them of large size. In old fragments the latter are fewer and of small size, and the zoœcial apertures more direct and polygonal. Closures with faint radiating lines; central perforation rather small. Measuring diagonally about six zoœcia in 1.5 mm.

Internal characters as shown in figs. 7 and 8. Vertical sections show that while diaphragms are rather abundant in all parts they are not excessively crowded in the peripheral region. In this respect the species differs from the species grouped about *C. multitabulata.*

The small size of the branches and bushy habit of growth distinguish the species from all the other known Minnesota species of the genus. Externally its zoaria are exceedingly like those of an undescribed form occurring in the Cincinnati quarries associated with *C. dalei* Ed. and H.

Formation and locality.—Very abundant in the upper third of the Trenton shales, rare in the Galena shales, at St. Paul and Cannon Falls, Minnesota.

Mus. Reg. No. 8112.

CALLOPORA PULCHELLA, *n. sp.*

PLATE XXII, FIGS. 1-12.

Zoarium dendroid, branches averaging 5 mm. in diameter, tapering slightly, the oldest parts sometimes attaining a diameter of 7 mm., the young extremities only 3 or 4 mm. The branches divide dichotomously at average intervals of 12 mm., and never, so far as observed, inosculate. Surface exhibiting small conical monticules, 2.0 to 2.5 mm. apart, their summits generally with small aggregations of mesopores. As shown in the figures, the hight of the monticules varies in different examples, and in some they are to be described as rounded rather than conical. Zoœcial apertures small, subcircular, enclosed by rather thick, ridge-shaped walls, regularly arranged, subequal, thirteen or fourteen in 3 mm. Mesopores very small and, though numerous, often difficult to distinguish externally with an ordinary pocket lens. This difficulty is greatest in old examples in which they are partially filled by calcareous deposits.

Internal characters: Vertical sections show that in the axial region the proximal end of the tubes is crossed by from two to four diaphragms, beyond which these structures are absent till we reach the middle of the comparatively wide peripheral region when each zoœcial tube is again intersected by one or two. Mesopores are abundant and closely tabulated. In tangential sections the zoœcia are subcircular, their walls somewhat ring-like and in contact with each other in only a limited degree, the interspaces being occupied by more or less numerous mesopores varying considerably in size and shape. Just beneath the surface of a fully matured example the walls are thickened by internal deposit, the mesopores small and approximately of uniform size. At deeper levels the walls are thinner and the mesopores larger and more irregular in shape and size. In transverse sections the axial region is made up of decidedly angular tubes of which those of the larger set are also comparatively small, while those of the minor set are less regularly distributed than usual.

This form is to be compared with the *C. dalei* Edwards and Haime, of the Cincinnati group, from which it differs chiefly in having fewer diaphragms and slightly smaller zoœcia. Excepting the following variety there is no Minnesota species of *Callopora* known that is likely to be confounded with *C. pulchella,* but care is required in separating it from the associated *Homotrypa tuberculata.*

Formation and locality.—Common in the upper third of the Trenton shales at St. Paul and near Cannon Falls, Minnesota.

Mus. Reg. Nos. 8033, 8114.

Callopora pulchella, *var.* persimilis, *n. var.*

PLATE XXII, FIGS. 13-17.

This variety differs from the typical form of the species in having more prominent tubercles, thinner zoœcial walls (causing the apertures to be correspondingly larger), more readily distinguished and, as a rule, more numerous mesopores, even fewer diaphragms, and in the greater size of the tubes in the axial region. The growth of the zoarium and the number of zoœcial apertures in 3 mm. (thirteen or fourteen) is the same. Indeed, the points of difference even are not constant. We cannot, therefore, doubt the propriety of referring the form to *C. pulchella.* On the other hand it is impossible to distinguish var. *persimilis,* by external comparison of fragmentary material alone, from the later *C. ramosa* d'Orbigny, one of the most common Bryozoa of the Cincinnati rocks. It is true the zoaria of the Trenton form never grew to such a size nor do the branches inosculate as in the Cincinnati species, but such differences the student will find of little practical use when, as usual, fragments are to be identified. Luckily, the interior furnishes us with a guide in the relative number of diaphragms, these being much more abundantly developed in the Cincinnati species than in the Trenton variety. For further remarks relating to this subject see *ante.* p. 215.

Formation and locality.—Associated with *Phylloporina corticosa, Trigonodictya conciliatrix* and *Prasopora conoidea,* all characteristic species of the upper third of the Trenton shales, at Poe's farm, near Cannon Falls, Minnesota.

Mus. Reg. No. 8115.

Callopora crenulata, *n. sp.*

PLATE XXII, FIGS. 18-23.

Zoaria forming rather large, compactly interwoven, bushy masses, consisting of strong branches that divide and inosculate most irregularly and frequently; average thickness of branches 7 or 8 mm., but some may be over 10 mm., and as many only 4 or 5 mm. Surface generally with rounded monticules, occupied by clusters of zoœcia larger than the average, and by greater or less aggregations of small mesopores. Zoœcial apertures rounded, mostly subcircular, regular, twelve or thirteen in 3 mm. Closures preserved in one out of about forty specimens, slightly concave, apparently smooth and without a raised rim about the central perforation. Walls of moderate thickness, ridge-shaped. Mesopores numerous, rather small, but distinctly visible under a good pocket lens.

Internal characters: These are remarkable chiefly in vertical sections, tangential and transverse sections being very much like those of *C. pulchella* and *C. ramosa.* In vertical sections namely there seems to be a total absence of diaphragms, not only in the zoœcial tubes but in the mesopores as well. Another peculiarity is the crenulated or wavy character of the walls in the axial region that has suggested the specific name. This crenulation is shown very distinctly when the tubes are exposed by vertical fractures.

The two peculiarities mentioned in the preceding paragraph distinguish the species from all the others now referred to the genus. In other respects we are reminded of its associate *C. pulchella*, yet they ought in no case to be confounded, since in that species the branches are more slender and do not inosculate, and the zoœcial apertures are appreciably smaller.

Formation and locality.—Not uncommon in the upper third of the Trenton shales at St. Paul and near Cannon Falls, Minnesota. Rare in the Galena shales (here almost invariably without monticules) at the same localities, and at Decorah, Iowa, and Neenah, Wisconsin.

Mus. Reg. Nos. 8019, 8038, 8068, 8082.

Family DIPLOTRYPIDÆ, Ulrich.

For remarks on this family see pp. 276 and 290.

Genus DIPLOTRYPA, Nicholson.

Zoaria massive or discoid, generally free. Zoœcial tubes comparatively large, with thin prismatic walls, and horizontal diaphragms. Mesopores few to numerous, varying in size, many of them enlarging gradually and assuming the characters of true zoœcia. Acanthopores wanting.

Type: *D. petropolitana* Pander, sp.

The relations of this genus are with *Batostoma* on the one hand and *Monotrypa* and *Callopora* on the other. Species are few and, so far as known, all belong to Lower Silurian rocks. The two about to be described are aberrant in having very few mesopores.

DIPLOTRYPA LIMITARIS, *n. sp.*

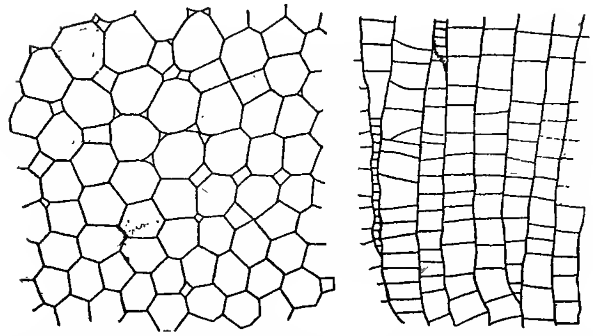


FIG. 18. *Diplotrypa limitaris* Ulrich, upper beds of the Galena shales, Goodhue county, Minnesota. Collection of E. O. Ulrich. Transverse and vertical sections, x 18, showing the tabulation of the tubes and the great reduction in the number of mesopores characterizing the species.

Zoarium, as seen in four specimens, small, hemispherical, 12 mm. or less in diameter, and 3 to 7 mm. in hight. Under surface concentrically wrinkled; upper surface without monticules but presenting rather conspicuous clusters of large cells among which the mesopores are commonly more numerous than elsewhere. Walls very thin; zoœcial apertures polygonal, 0.25 to 0.4 mm. in diameter, with ten to twelve in 3 mm. Mesopores of variable size, not as numerous as the zoœcia. Tabulation of tubes comparatively regular and uniform; in the mesopores there are nine or ten diphragms in 0.5 mm., in the zoœcial tubes six to nine in 1 mm. As shown at the margin of the vertical section figured above, the tabulation of the mesopores changes suddenly (? always) into that of the zoœcia.

The unusually small number of mesopores distinguishes this species from *D. petropolitana* and *D. westoni* (Ulrich). In those species the zoœcia are also somewhat larger, and the tabulation less uniform.

Compared with associated and other discoidal Bryozoa, the species of *Mesotrypa* are separated by their rounded zoœcia and much more abundant mesopores, those of *Prasopora* by the cystiphragms, those of *Leptotrypa* by their acanthopores, while those of *Monotrypa* are entirely without mesopores.

Formation and locality.—Upper beds of the Galena shales at localities in Goodhue county, Minnesota. The best exposure of these beds is in a bluff about thirteen miles south of Cannon Falls.

DIPLOTRYPA NEGLECTA, *n. sp.*

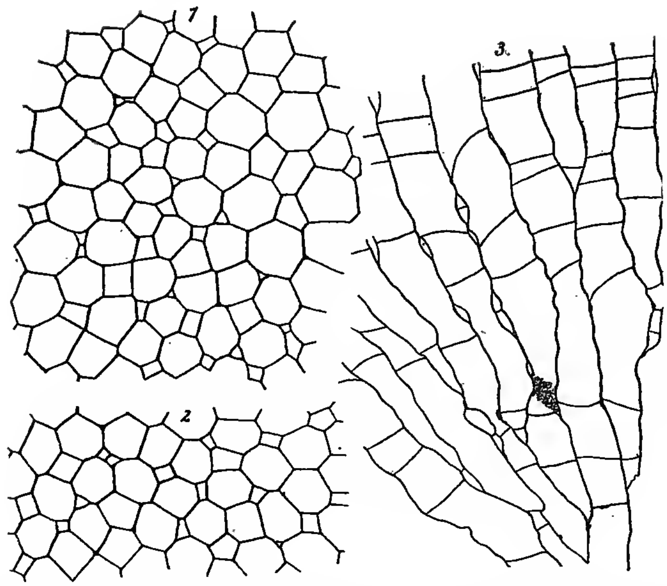


FIG. 19. *Diplotrypa neglecta* Ulrich, base of Galena limestone, Hader, Goodhue county, Minnesota. Collection of E. O. Ulrich. 1 and 2, two tangential sections, x 18, and 3, a vertical section, similarly enlarged.

Zoarium a small subconical or hemispheric mass, about 12 mm. in diameter and 8 mm. in hight. Tube walls thin, transversely rugose, appearing quite irregular and rough in longitudinal fractures. Zoœcia about nine in 3 mm., not regularly arranged, polygonal, largely in contact with each other, the mesopores being few in number and variable in size and distribution. Clusters of large zoœcia occur and among these the mesopores may be more abundant than in the intermediate spaces.

In transverse sections we see cells of all sizes up to 0.45 mm., and not infrequently it is difficult to discriminate between the smaller zoœcia and the mesopores. As is shown by vertical sections the two sets of tubes are not totally distinct, the mesopores being in many cases clearly superseded by zoœcia. Perhaps on account of the rugosities of the walls the mesopores often appear as developed periodically. The diaphragms are irregularly distributed, from one-half to four times their diameter distant in the large tubes and averaging about 0.15 mm. apart in the mesopores.

Though possessing all the essential characters of the genus, the internal irregularly and other peculiarities of the species are so obvious that comparisons are unnecessary.

Formation and locality.—Lower part of the Galena limestone, at Hader, Goodhue county, Minnesota. It is here associated with *Mesotrypa* (?) *rotunda* Ulrich, *Plectambonites gibbosus* W. and S., *Pleurocystites angulatus* Ulrich, *Fusispira ventricosa* Hall, and other fossils described in this volume.

Genus BATOSTOMA, Ulrich.

Batostoma ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 154; 1890, Geol. Sur. Ill., vol. viii, pp. 379, 459; FOORD, 1883, Contri. Micro-Pal. Cam.-Sil. rocks Can., p. 17.

Zoaria irregularly ramose, with a large basal expansion. Zoœcial walls thin, and irregularly flexuous in the axial region, more or less thickened in the peripheral. In the most typical species the walls are irregularly ovate, thick and ring-like in tangential sections, with neighboring zoœcia in contact only at limited points, the mesopores numerous, closed at the surface, and irregular in shape and size, and the acanthopores abundant and with a larger central cavity than usual. Species vary from these to forms having polygonal, thin-walled zoœcia and very few mesopores and acanthopores. Diaphragms strong, horizontal, complete, few or wanting in the axial, more or less abundant in the peripheral region. In the axial region of transverse sections the tubes are divisible into two sets, one larger than the other.

Type: *B. implicatum* Nicholson, sp.

Beginning in the Birdseye limestone and shales of Minnesota with *B. fertile*, *B. magnopora*, and an undescribed species, it is evident that, the same as with *Callopora* and *Dekayella*, the primitive stock of the genus was of the simplest type. Mesopores were few, the zoœcia angular and thin-walled, and acanthopores both few and very small. And yet the first of these species varies by most gentle degrees to forms (*B. fertile* var. *circulare*) having numerous mesopores, circular zoœcial apertures, and thick walls—in short to a form that approximates the most typical and fully developed species of the genus.

In *B. implicata* and *B. jamesi* Nich. sp., of the lower half of the Cincinnati group, the zoœcia are characterized by thick ring-like walls, irregularly oval apertures, numerous mesopores and acanthopores. Although closely allied, *B. variabile* differs conspicuously from them in having few mesopores and polygonal zoœcia. Being a later species, and one that doubtlessly is a direct descendant of those forms, we are justified in assuming that a reversion in structure toward the primitive type took place during the closing times of the Lower Silurian. While such a tendency seems to have been general it was by no means universal, since at certain localities (Stony Mountain, Manitoba, Iron Ridge and Delafield, Wisconsin) where the conditions for the development of these Bryozoa seems still to have been eminently favorable, the genus is represented by species with abundant mesopores.

A similar reversion had already taken place during the deposition of the Utica, in which two of the species, both as yet undescribed, are so simple in their structure that their really intimate relations to *B. jamesi* might not be suspected. It is only by making large collections that the affinities of such species can be determined. When this can be done we find that some specimens exhibit, perhaps over limited areas only, the full characters of the genus in an indubitable manner.

The mesopores, therefore, are to be considered as the most unstable feature of *Batostoma.* Though they can never be said to be wanting entirely, it is nevertheless true that an inexperienced student might occasionally come to such a conclusion. Even in the same species great differences in their number may be encountered. Take *B. fertile,* for instance, in which such deviations are more strikingly expressed than in any other species (compare figs. 4 and 7 with 8 and 9 on plate XXV). On the other hand the peculiar irregularity of the tubes in the axial region seems always to be present, thus assuring us of a clue to the generic affinities of forms that, because of the almost total lack of mesopores and practical absence of acanthopores may appear to have relations with types differing widely from *Batostoma.*

Respecting the affinities of the species of *Batostoma* and the systematic position of the genus, I have always been in some doubt. At first the *Heterotrypidæ* seemed the most likely family to receive them, but I soon satisfied myself that their relations did not lie in that direction. Next the *Calloporidæ* were suggested, and finally, as vol. viii of the reports of the Geological Survey of Illinois was going through the press, I decided to place them with the *Diplotrypidæ,* and it is with this family that I have since arranged them. To-day another arrangement would suit me better. The fact is that most of my time since the printing of the Illinois work has been spent on the Bryozoa, and the last six months were devoted to the *Trepostomata* exclusively. Innumerable comparisons were drawn, many of them resulting in important genealogical discoveries. But as is intimated on p. 216, the changes in classification that would be necessary, if the results of my comparative studies were carried to a logical conclusion, seemed too numerous and great for the present state of published knowledge. Indeed, I feared that under the prevailing circumstances it would be difficult to substantiate my claims. It should be remembered that I work from a basis, or rather with a knowledge of paleozoic bryozoan forms that exceeds the published lists by several hundred species. Even with the conservative plan adopted by me, I am obliged continually to draw upon unpublished matter to prove my points, so that only too often they narrowly escape standing as mere assertions. Among other changes that I should have liked to make in the scheme of classification on pp. 105–107, is a reconstruction of the families *Calloporidæ, Diplotrypidæ* and *Trematoporidæ.* In the first place it was a mistake to make *Trematopora* the type of the family as defined, because the relationship to *Constellaria,* which more truly expresses the characters of the family intended, is remote compared with the affinities existing between *Trematopora* and *Batostoma.* The latter, I am now fully satisfied, embraces the progenitors of *Trematopora*, and as the relationship seems to be very intimate it may be well to consider the advisability of dropping *Batostoma* in favor of Hall's older name. The *Calloporidæ*, with *Aspidopora* removed to the *Monticuliporidæ*, might be united with the *Diplotrypidæ*, from which, in that case, it would be well to remove *Batostoma*.* But for the reasons stated it was deemed inexpedient to carry out sweeping innovations in the present work, and the only excuse for their mention here is that it seemed necessary to publish some idea of the lines in which progressing knowledge is likely to modify the present classification. Perhaps also to show how well we are acquainted with its imperfections.

BATOSTOMA FERTILE *Ulrich*.

PLATE XXV, FIGS. 1-11.

Batostoma fertile ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 92.

Zoarium attaining a large size, 50 to 100 mm. in hight, consisting of strong, irregularly thickened, more or less compressed branches that divide without regularity; thickness of branches 5 to 25 mm., width 8 to 30 mm. Zoœcial apertures varying according to the size and number of the mesopores and the thickness of the walls, from polygonal to circular. In some specimens and portions of others mesopores are exceedingly few and the zoœcial walls thin and generally in contact at all sides; in the majority of examples mesopores are moderately abundant and the walls thicker, but the zoœcial apertures are still polygonal or at any rate most of them subangular. From this, the typical form, we can trace the variations by small degrees into a form which, for the sake of reference, may be designated as var. *circulare*. In this the zoœcial apertures are almost perfectly circular, enclosed by a raised rim or peristome, and largely separated from each other by depressed interspaces. Often the peristomes are thicker and more distinctly separated from each other than is shown in fig. 6. Interspaces occupied by mesopores varying considerably in size and shape. Their mouths are commonly closed by a calcareous plate in which a variously situated rounded opening may be observed. When the preservation is unusually favorable the surface of the plate is studded with very minute papillæ representing the terminations of exceedingly small foramina. Acanthopores between one and two to each zoœcium, but very small and only in rare instances distinguishable at the surface. At intervals of 3 or 4 mm. occur clusters of zoœcia a little larger than the average, and in the center of these usually small substellate maculæ. Between eight and nine of the average zoœcia in 3 mm.

*The families reconstructed in accordance with the above suggestions would be as follows: CALLOPORIDÆ, *Callopora, Diplotrypa, Monotrypa, ? Calloporella*; TREMATOPORIDÆ, *Trematopora, Batostoma, ? Hemiphragma, ? Stromatotrypa*; CONSTELLARIDÆ, *Constellaria, Stellipora, Nicholsonella, ? Idiotrypa*.

Internal characters: In vertical sections the tubes have thin and somewhat irregularly fluctuating walls in the axial region. Their course to the surface is gently curved throughout, and as they near the same their walls are appreciably thickened, while mesopores, whose number varies greatly in different specimens, are abruptly developed. The mesopores may be constricted at the points where they are intersected by the diaphragms. The latter are often thickened circumferentially, and vary somewhat in the number occurring in a given space, seven and eleven in 1 mm. being the extremes so far noticed. In the axial region diaphragms are very far apart or are wanting entirely, but in the peripheral portion the average distance between them is about equal to half their diameter. Specimens more than 12 mm. thick consist of two or more layers of tubes.

The four tangential sections figured on plate XXV, fully illustrate the characters of the species as brought out in this kind of section. Fig. 7 is from a specimen with very thin walls, few mesopores, and scarcely distinguishable acanthopores, the latter being in the angles of junction. Fig. 4 represents a small portion of a section prepared from the original of fig. 2. In this, which is an average example, the walls are thicker, mesopores more abundant, and the acanthopores, though small, more readily distinguished. Minute foramina are shown in the diaphragms of some of the mesopores. Figures 8 and 9 are from specimens of the variety *circulare*, the first with thick zoœcial walls, the second with them thin as in fig. 6.

In a general way this species reminds one more of upper Hudson river species than of Trenton forms. Variety *circulare* resembles *B. manitobense* Ulrich,* very closely, but the clusters of large zoœcia are more conspicuous in that species. The typical variety on the other hand is more like *B. variabile*, differing from it chiefly in the smaller size of the acanthopores. Compared with associated Bryozoa none save *Anolotichia impolita* have as large zoœcia.

Formation and locality.—Abundant in the lower third of the Trenton shales at Minneapolis and St. Paul, Minnesota.

Mus. Reg. No. 8136; var. *circulare*, 8137.

Batostoma magnopora, *n. sp.*

PLATE XXV, FIGS. 12-15.

Zoarium ramose; branches large, subcylindrical, 8 to 15 mm. wide; surface elevated at irregular intervals into low monticules, the latter broad and occupied by zoœcia a little larger than the average. Zoœcia unusually large, about eight in 3 mm., their apertures polygonal, the walls thin, with one or two small acanthopores

*Contr. Micro-Pal. Cambro-Sil. rocks of Canada, pt. II, p. 33, 1889.

to each zoœcium rising generally from the wall at some point between the angles of junction. Many of the latter are occupied by small mesopores, but these are to be regarded as comparatively very few and at all times difficult to distinguish externally.

Internal characters: In tangential sections the tubes are polygonal and have rather thin walls in which the line of contact between adjoining tubes is distinctly preserved. Mesopores few, small, chiefly at the angles of junction. Acanthopores small, inconspicuous. In vertical sections the tubes proceed toward the surface in a very gentle curve until they enter the unusually narrow peripheral region, where the curve is sufficiently accelerated to enable them to open at the surface with nearly direct apertures. Diaphragms are very remote or wanting in the axial region, and not numerous even in the peripheral portion. Here each tube presents from one to five, separated by intervals of from one-half to one tube-diameter. In the mesopores, which appear to be very short, the diaphragms are much closer with three or four in 0.5 mm. In the central part of transverse sections (fig. 14) the tubes are conspicuously divided into a large and small set, both having very thin walls.

The large size of the zoœcia distinguishes this species not only from all the other forms of the genus known but from all the associated bryozoans as well. *Anolotichia impolita*, restricted to the bed of shales immediately beneath ("Stictoporella beds"), has zoœcia fully equalling those of the present species in size, but they are each provided with a lunarium and are commonly of either rhomboidal or hexagonal shape, while the surface is without monticules and the growth of the zoarium decidedly irregular.

Formation and locality.—Four specimens were found in the middle third of the Trenton shales, three at Minneapolis, the fourth at West St. Paul.

Batostoma varium, *n. sp.*

PLATE XXV, FIGS. 16-25.

Zoarium growing from a large basal attachment into erect branches. These vary in width from 7 to 20 mm. but average from 10 to 15 mm., are generally a little compressed and divide most irregularly. In some cases the basal expansion consists of several distinct layers, varying from 1 to 3 mm. in thickness. Surface without monticules, but exhibiting instead clusters of orifices larger than the average and separated by interspaces wider than usual. Not infrequently the center of these clusters is marked by a small substellate solid macula. Superficial characters variable, the walls in some cases being thin, with the zoœcial apertures subangular, the zoœcial walls seemingly in contact in most cases, the mesopores few, and the acanthopores indistinct. This condition, which is to be counted as rare, corresponds to fig. 18. From it the usual deviation consists in the rounding and constriction of the zoœcial apertures, and widening of the interspaces. When carried to the extreme we have subcircular apertures enclosed by a thin peristome, separated by depressed interspaces in which the mouths of a few mesopores may be noticed. In all these conditions (corresponding to figs. 16, 19, 20 and 21) the average number of zoœcial apertures in 3 mm. is nine or ten. The acanthopores also are rarely very conspicuous for size, though they are numerous enough and may be distinctly visible on well preserved examples. But in a variety, or rather an occasionally observed condition of the species, the acanthopores are much larger and situated three or four in the now thin walls of each zoœcium, causing their apertures to be more or less indented at the points occupied by them.

Internal characters: The extreme variability of tangential sections is well shown in the seven figures on plate XXV. And yet the species is an easy one to identify by means of thin sections. Each tangential section will show from two to four of the conditions illustrated, and although I used five specimens and six sections I might have obtained an equal range of variation with two of them. The greater part of them vary between the appearances represented in figs. 16, 19 and 21. Vertical sections are more constant, having numerous diaphragms—about four in the zoœcial tubes and six in the mesopores in 0.5 mm.—in the peripheral region, and none in the axial. The usual irregularity of the tubes in the axial region is noticeable. Also a peculiar moniliform structure of the walls in the peripheral region is the probable cause of some of the variations noticed in tangential sections.

The zoarial growth is less robust and the average size of the zoœcia less than in *B. fertile*. The opposite is the case when compared with *B. winchelli*, which, like *B. minnesotensis*, has also much fewer mesopores. The species is evidently a forerunner of *B. humile* of the Galena shales and *B. jamesi* Nich. sp. of the Cincinnati rocks.

Formation and locality.—Moderately abundant in the middle third of the Trenton shales at Minneapolis and St. Paul, Minnesota.

Mus. Reg. No. 8135.

Batostoma montuosum, *n. sp.*

PLATE XXV, FIGS. 26-28.

Zoarium ramose, small, branches dividing rapidly, 5 to 10 mm. in diameter; surface with more or less conspicuous monticules, 2.0 or 2.5 mm. apart, occupied by apertures of the same size as those in the depressions; the summit of the monticules occasionally appearing subsolid. Acanthopores numerous, rather small, often indenting the zoœcial apertures. Interspaces variable, occupied by closed mesopores, often thinner and the zoœcial walls more in contact with each other than shown in fig. 27. About ten zoœcial apertures in 3 mm.

None of the specimens at hand have preserved the internal characters in a fully satisfactory manner. The sections prepared, however, are sufficiently clear to make the generic reference of the species unquestionable. They point, furthermore, to close relationship with *B. varium*, differing from that species in having the peripheral region narrower and diaphragms less abundant. Of external peculiarities the possession of well marked monticules distinguishes the species from all related forms. For comparisons with associated monticulose species belonging to other genera see p. 227.

Formation and locality.—Not uncommon in the upper third of the Trenton shales at Poe's farm, near Cannon Falls, Minnesota.

Mus. Reg. No. 8134.

Batostoma humile, *n. sp.*

PLATE XXV, FIGS. 29-36.

Zoarium rather small, consisting of comparatively slender, compressed or subcylindrical branches, 4 to 11 mm., commonly 5 to 7 mm., in width; bifurcations few, less frequent than usual with species of this genus; surface without monticules, but more or less strongly spinulose in the older stages. Zoœcial apertures subovate, varying in size according to thickness of walls and interspaces, generally with a thickened rim; apertures subequal, eight or nine in 3 mm. Interspaces variable, depressed, the zoœcial walls sometimes in contact at as many points as the rounded form of the tubes will admit; more commonly their walls are completely separated. At intervals the interspaces may widen and form subsolid spots. Acanthopores numerous, situated in the interspaces or on the outer side of the walls, small and often difficult to distinguish on young examples, but conspicuous enough on well matured specimens and very much so on several apparently old fragments. In the latter the interspaces may be solidified and raised instead of depressed, and the size of the zoœcial apertures 0.15 by 0.2 mm. against 0.2 by 0.3 mm. in young specimens.

Internal characters: Good tangential sections cannot be prepared except from fully matured or old examples, because of the brevity of the peripheral region. Young specimens give tangential sections like the upper half of fig. 33, with thin walls and angular zoœcia. With age the walls become thickened, ring-like and more or less separated by partially filled mesopores. The acanthopores also increase in size and distinctness but, being situated either in the interspaces or on the outer side of the zoœcial walls, never encroach upon the zoœcial cavities. In the axial region of vertical sections the tubes have irregularly undulating thin walls and no diaphragms. Nor are these structures developed except in the unusually narrow peripheral region, where from one to three have been observed in each tube. The mesopores are very short and provided with two or three thick diaphragms; or they may appear to be filled with solid tissue.

The oval zoœcial apertures, more slender growth, and absence of monticules are the most striking differences between the present species and *B. montuosum.* The zoarium is smaller, the branches more slender, and the peripheral region much narrower than in *B. varium.* An undescribed variety of *B. jamesi* Nich. sp., occurring in the Utica horizon at Cincinnati, Ohio, corresponds more nearly than any of the known Minnesota species of the genus.

Formation and locality.—Moderately abundant in the Galena shales at St. Paul and near Cannon Falls, Minnesota. Also at Decorah, Iowa. A similar, perhaps identical, species occurs in the Trenton of central Kentucky.

Mus. Reg. Nos. 7613, 8063.

Batostoma winchelli *Ulrich.*

PLATE XXVI, FIGS. 33-37; PLATE XXVII, FIGS. 1-6.

Amplexopora winchelli Ulrich, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 91.

Zoarium irregularly ramose; branches subcylindrical or a little compressed, varying in diameter from 4 to 10 mm., but in nine-tenths of the fragments seen from 5 to 7 mm. In the typical and common form of the species monticules are wanting, nor are the clusters of apertures of larger size than the average, which sometimes take their place, ever a conspicuous feature. Occasionally they are rendered more distinct than usual by a thickening of the interspaces and an aggregation of the mesopores. In a variety that may be distinguished as *nodosa,* the surface is thrown up into more or less strongly marked monticules. Zoœcial apertures rounded or subangular, rather irregularly arranged, ten to twelve in 3 mm.; walls moderately thick in most specimens, comparatively thin in young, very thick in worn old ones, ridge-shaped when perfect, and with acanthopore spines at nearly all angles of junction. Mesopores sparingly developed, never as numerous as the zoœcia, occurring chiefly in small straggling clusters, their mouths open, of various sizes, some of them apparently developing into zoœcia.

Internal characters: Being an exceedingly common and superficially variable species, over thirty sets of thin sections were prepared. These prove the species constant in most of the characters shown in vertical sections, and decidedly variable in tangential sections. It should, however, be stated that many of the specimens sectioned exhibited some external peculiarity or deviation from the ordinary types of the species. In the axial region of vertical sections the tubes are thin-walled and crossed by diaphragms from one to three times their diameter distant from each other. But in the attenuate proximal ends of the tubes the diaphragms are always closer than after the tubes have attained their full size. In entering the peripheral region, the width of which depends upon age, the tubes bend outward rather abruptly, proceeding thereafter directly to the surface. In the turn the diaphragms become more numerous and, though generally straight and complete, not infrequently exhibit a tendency to coalesce with each other. In the mesopores, which sometimes evidently changed into zoœcial tubes, the diaphragms occur regularly seven in 0.5 mm.

In figs. 4 to 8 on plate XXVII, I have endeavored to represent the principal variations noticed in tangential sections. The most of them are as in fig. 6, and figs. 4 and 5 represent what I regard as a condition of extreme age, differing from the usual condition merely in having an extra internal deposit of hard tissue. Figs. 7 and 8, however, deviate in a more important respect in having stronger and more abundant acanthopores. Many of these, furthermore, are developed between the angles, causing an inbending of the tube-walls. The average size of the zoœcia in this form, which may receive the provisional name of var. *spinulosum*, is also a trifle greater than usual.

The systematic position of this and the two species following is somewhat doubtful, but after careful reflection I have selected *Batostoma* as more fitting to receive them than *Amplexopora*. The closer tabulation of the proximal ends of the tubes, the irregularity of the tubes in the axial region, and their division there (as seen in the central part of transverse sections) into a large and small series, are characters so far unknown in *Amplexopora*. But my chief reason for placing the species with *Batostoma* is found in the marked resemblance exhibited by fig. 8 to similar views of *B. implicata* and *B. jamesi* of the Cincinnati rocks.

Formation and locality.—Very abundant in the middle third of the Trenton shales at St. Paul, Minneapolis, and localities in Goodhue and Fillmore counties, Minnesota.

Mus. Reg. Nos. 5999-6001, 8092, 8095.

Batostoma minnesotense, *n. sp.*

PLATE XXVI, FIGS. 38-40; PLATE XXVII, FIGS. 9-15.

Amplexopora superba Ulrich, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 92. (Not Foord, 1883, Contri. Micro-Pal. Cambro-Sil. Rocks, Can., p. 16.)

Zoarium ramose, above the medium size for the genus; branches without monticules, subcylindrical, bifurcating at rather long intervals, averaging 9 or 10 mm. in diameter, but varying between the extremes of 7 and 15 mm. Zoœcial apertures subangular, with walls of moderate thickness, arranged in regular curving series about clusters of orifices that are in most cases decidedly larger than the average; of the latter sometimes nine, more often ten, occur in 3 mm. Prominent acanthopores at all the angles of junction, and in many cases another is placed between the angles. These at all times occupy the summit or center of the walls and in no case cause irregularities in the form of the zoœcial apertures. Mesopores very few, scattered at random among the larger apertures.

Internal characters: In tangential sections the walls are nearly uniformly thick, with the angles of junction often appearing as open (pl. XXVII, fig. 15). In other cases the angles are occupied by dark spaces looking more like the usual appearance of acanthopores. A more typical phase of the species is shown in figs. 9 and 10, representing parts of a section of an excellently preserved example. In this we have more abundant acanthopores and the cavity in these is unusually large, while many of the angles are occupied by open spaces similar to those shown in fig. 15.

In vertical sections the tubes are provided with thin wavy walls in the axial region, where they are also a little irregular and generally entirely without diaphragms, the latter first making their appearance as the tubes bend into the peripheral region. In the outer region the walls are much thickened and in places distinctly traversed longitudinally by acanthopores. The mesopores are but seldom observed, have few diaphragms and appear to be in part filled with solid tissue. The arrangement of the diaphragms in the zoœcial tubes varies somewhat in different sections. Figures 11 and 13 represent extremes in this respect.

This species, though closely related to *B. winchelli*, is readily distinguished externally by its larger size and slightly larger and more regularly arranged zoœcial apertures; internally by the wavy walls and the absence of diaphragms in the axial region. Foord's *Amplexopora superba*, to which I at first referred this species, is probably congeneric, but distinguished specifically by having nearly straight instead of wavy walls to the axial tubes, and a tuberculated surface.

Formation and locality.—Not rare in the middle third of the Trenton shales at Minneapolis, St. Paul and other localities in Minnesota.

Mus. Reg. Nos. 5996, 5998, 7592, 7668, 8093.

Batostoma? decipiens, *n. sp.*

PLATE XXVII FIGS. 16-19.

Zoarium ramose, branches smooth, 5 to 12 mm. in diameter. Zoœcia with moderately thick walls; apertures polygonal, subequal, about eleven in 3 mm. When in a good state of preservation the walls are sharply ridge-shaped, appearing thinner than usual. Clusters of large cells scarcely distinguishable. Mesopores very few, acanthopores not observed at the surface.

Internal characters: Vertical sections show that in the axial region the proximal end of the tubes is crossed by four to six diaphragms, 0.2 mm. or less apart. Above these the distance between them is from two to four times as great until the tubes are about to turn into the well defined peripheral region, when their number is greatly increased. In the outer part of the tubes, where the diaphragms also exhibit a tendency to coalesce, the number varies in different sections from seven to twelve in 0.5 mm.

In tangential sections the walls are thick, though some difference in this respect is noticeable in the ten sets of sections prepared. This is owing to the varying thickness of the internal concentrically laminated deposit. The divisional line between adjoining tubes is sharply marked, and sometimes contains a small, acanthopore-like dot midway or thereabout between the angles of junction. The mesopores, which are scattered very sparingly among the zoœcia, and sometimes gathered into clusters of three or four, look very much as though they might be merely young or perhaps aborted zoœcia, differing from them, so far as can be seen in these sections, solely in the matter of size.

The systematic position of this species cannot be determined finally until we know more of the Chazy *Trepostomata*. Without that knowledge its affinities appear to lie as closely with *B. winchelli* on the one hand as with *Callopora angularis* on the other. I thought much of classing the species with *Callopora*, but at last concluded that the occasional presence of acanthopores and greater thickness of the walls would not now admit of such an arrangement. *Callopora angularis*, which of all the associated species is probably the most like *B.? decipiens*, has smaller branches and thinner zoœcial walls.

Formation and locality.—Rather rare in the lower and middle third of the Trenton shales at Minneapolis, Minnesota.

Genus HEMIPHRAGMA, n. gen.

Batostoma (part.) ULRICH, 1890. Geol. Surv. Ill., vol. viii, p. 379.

Zoaria like those of *Batostoma* save in this, that the diaphragms in the peripheral part of the zoœcial tubes are incomplete.

Type: *Batostoma irrasum* Ulrich.

The discovery of a fourth species having incomplete diaphragms has decided me in giving the character generic rank. What may prove to be a fifth species, occurs among my material from the upper beds of the Hudson river group at Delafield and Iron Ridge, Wisconsin. Unfortunately, the Bryozoa which occur so abundantly at those localities do not preserve the internal characters, so that in cases like this it is impossible to verify the generic affinities of the species by means of thin sections. It is possible that the natural relations of *Hemiphragma* are not with *Batostoma*, but in the absence of data showing the value of the difference between the two genera, we are obliged to place them together because of their marked agreement in all other respects.

HEMIPHRAGMA IRRASUM *Ulrich.*

PLATE XXIV, FIGS. 5-19.

Batostoma irrasa ULRICH, 1886. Fourteenth Ann. Rept. Geo. Nat. Hist. Sur. Minn., p. 94.

Zoarium consisting of small, subcylindrical, frequently and rather irregularly dividing branches, commonly 5 or 6 mm. in diameter, but varying from 4 to 8 mm., the latter extreme probably only when an extra layer of tubes has grown over the original branch. Monticules wanting, but under fully matured conditions the surface is abundantly spinulose. Zoœcia with subangular apertures and thin walls when young, and with smaller, subcircular or oval apertures and more or less thick walls in fully matured examples; arrangement of apertures rather regular in rows about small solid spots, in the immediate vicinity of which the zoœcia may be of larger size than elsewhere; seven to nine in 3 mm. Interspaces apparently solid and generally with shallow irregular depressions in most specimens, but in very young stages a variable number of irregular mesopores may be recognized. Acanthopores numerous, two or more to each zoœcium, situated in the angles of junction and interspaces, and increasing in size with age. They are large and a conspicuous external feature of well preserved mature examples.

Internal characters: In the axial region of vertical sections the tubes have thin and irregularly fluctuating walls, and few or no diaphragms. The latter are complete here and the proximal end of the tube expands to full size with unusual rapidity. In the peripheral region, which is narrow and abruptly distinguished from the axial, the walls are more or less thickened, and the tubes intersected by semi-diaphragms, about four in 0.5 mm. I have satisfied myself that all the transverse partitions in this outer part of the zoœcial tubes are really incomplete. That many may appear entire in sections is only because their inner edge happens to be vertical instead of horizontal. Mesopores are difficult to make out in these sections, being short and usually filled, in part at least, with solid tissue. Tangential sections require no description, all the essential characters being shown in figs. 6, 7, 9 and 14. In the axial part of transverse sections the tubes are unusually irregular and their walls comparatively thick.

This is a common and well marked species, but proves to be nearer *H. ottawense* Foord sp., than I thought at first. Perhaps the only reliable difference, and that may in part be due to the greater size of Foord's species, is the much smaller number of diaphragms in *H. irrasum.* The largest specimens of the latter even do not approach *H. ottawense* in the width of the closely tabulated peripheral region.

Formation and locality.—Common in the lower third and rare in the middle and upper thirds of the Trenton shales at Minneapolis, St. Paul, and Preston. In the overlying Galena shales it is again common at St. Paul and at various localities in Goodhue county. Also at Decorah, Iowa.

Mus. Reg. Nos. 7618, 7627, 8033, 8041, 8051, 8078.

HEMIPHRAGMA OTTAWENSE *Foord.*

PLATE XXIV, FIGS. 1-4.

Batostoma ottawense FOORD, 1883. Contri. to Micro-Pal. Cambro-Sil. Rocks, Can., p, 18.

This species is so much like the preceding that it is sufficient to merely point out the differences between them. In the first place *H. ottawense* is always of larger size than *H. irrasum,* the width of its branches, which in some cases are strongly compressed, varying from 9 to over 30 mm., and their thickness from 8 to 12 mm. Internally, the axial region is comparatively smaller and the tubes here have diaphragms which, though sometimes wanting for short distances, are yet more abundant throughout the region than in *H. irrasum.* In the latter the peripheral region is narrow and the number of semi-diaphragms correspondingly limited. In the present species, however, this region is wide and the number of cross-partitions often great. The difference in these respects is generally quite as marked as in figures 3 and 5 on plate XXIV.

Foord says of the Canadian form of the species (*loc. cit.*) that the surface exhibits "small and inconspicuous monticules placed at variable distances apart and occupied by from ten to fifteen cells slightly larger than the average." The monticules are wanting in the specimens collected by me at Ottawa and in the Minnesota form, but smooth spots, consisting of clusters of mesopores, are present instead, and in the immediate vicinity of the spots the zoœcial apertures are larger than midway between them. It is possible that Mr. Foord was mistaken in crediting the species with monticules, since these spots, being more solid than the rest of the zoarium, are likely to withstand weathering better and thus to appear gradually as elevated points.

Formation and locality.—In Minnesota the species is rather rare and restricted to the upper part of the Galena shales at Kenyon, Berne and Mantorville. The same horizon contains *Fusispira ventricosa* Hall, *Orthis germana* W. and S., *Pachydictya pumila, Homotrypa similis, Monotrypa* (? *Chœtetes*) *cumulata*, and other highly characteristic fossils.

Mus. Reg. No. 6002.

Hemiphragma tenuimurale, *n. sp.*

PLATE XXIV, FIGS 20-23.

In its growth and general aspect this species is precisely like *H. irrasum.* Under a hand lens, however, they are immediately distinguished by the much thinner walls, fewer mesopores, and seeming total absence of acanthopores in the present species. In *H. irrasum* the zoœcial apertures also are always of rounded form, in *H. tenuimurale* angular. These differences, as may be seen from figs. 5 to 8 and 20 to 22 of plate XXIV, are no less obvious when we compare the internal characters of the two species. It is true, perhaps, that we may occasionally see faint evidence of very small acanthopores at the angles of junction in tangential sections, yet they are too indistinct and small to compare with the acanthopores of *H. irrasum.* In tangential sections the species is much more like *H. imperfectum* (*Batostoma imperfectum* Ulrich) of the Hudson river group of Illinois and Wisconsin. But that species grows to a much greater size and has rather conspicuous clusters of mesopores. *H. ottawense*, besides being much larger and having more abundant semi-diaphragms, differs in the same manner as *H. irrasum*.

Formation and locality.—Not uncommon in the Galena shales at various localities in Goodhue county, Minnesota.

Mus. Reg. Nos. 8032, 8042, 8052.

Genus STROMATOTRYPA, n. gen.

Zoarium consisting of one or several superimposed thin layers growing upon foreign bodies. Zoœcial tubes short, with few diaphragms, the proximal end scarcely prostrate, oval in cross-section; walls thin, containing periodically constricted, bead-like tubuli (? modified acanthopores), one or more to each zoœcium, Apertures oval, separated by depressed interspaces, the peristomes minutely papillose. Mesopores abundant, beginning on the basal lamina, decreasing in size with age, closely tabulated, the diaphragms finely punctured; mouths rarely visible, closed by a common dermal sheet. True acanthopores wanting.

Type: *Stromatotrypa ovata,* n. sp.

The species upon which this genus is based has much to remind us of the Devonian *Pinacotrypa,* Ulrich. But as that genus is clearly a branch of the *Fistuliporidæ,* and *Stromatotrypa* most likely not far removed from *Batostoma* and *Trematopora,* it is evident that there can be no real affinity with *Pinacotrypa.* The arrangement with the *Diplotrypidæ,* though provisional, is strongly suggested by the dimorphic character of the zoarium and the supposed relationship to *Bastostoma.*

STROMATOTRYPA OVATA, *n. sp.*

PLATE XXIV, FIGS. 24-31.

Zoarium consisting of one or more exceedingly thin layers, varying in thickness from 0.5 to 2.0 mm., occasionally attached to shells, but more commonly encrusting other Bryozoa. Sometimes the attachment is incomplete, and in a few cases the zoarium is free, with the underside wrinkled. Surface without monticules, but exhibiting at irregular intervals smooth spots of greater or less extent on which the zoœcia are generally farther apart than usual and the apertures of some of them closed. Zoœcial apertures oval, peristomes thin, in contact at limited points or more or less widely separated, the arrangement inclining to be irregular, with six to eight, commonly seven, in 3 mm.; length of apertures varying from 0.3 to 0.45 mm., the average about 0.28 by 0.38 mm. Interspaces depressed, of variable width, apparently smooth in the youngest stages, minutely granulose in the aged conditions. Small acanthopore-like elevations generally where peristomes come into contact. The best preserved specimens exhibit also a row of minute papillæ crowning the peristomes.

Internal characters: In tangential sections the zoœcial walls are thin and in contact at one or more points, or they may be completely isolated by mesopores varying considerably in shape and size. Attached to the walls, or more frequently occupying the angles of junction, are minute rounded and thin-walled cells that are perhaps to be regarded as peculiarly modified acanthopores. Good sections show besides a large number of smaller dots in the interspaces and zoœcial walls. In vertical sections both sets of tubes rise abruptly from the basal lamina, and the mesopores decrease more or less conspicuously in size in nearing the surface.

Diaphragms are few in the zoœcial tubes, but in the mesopores, which are usually constricted at the point of crossing, they are abundant. Here and there the zoœcial walls seem to diverge periodically so as to produce minute beaded tubuli.

There is no parasitic bryozoan known to me from Lower Silurian rocks with which this species could be confounded. Ramose Bryozoa coated with it might be mistaken for certain varieties of *Batostoma fertile*, but the crusts are rarely complete enough to render such a difficulty common. A greater superficial resemblance even is sometimes presented to young examples of *Pachydicta foliata*, a truly bifoliate species, with very different internal structure and really so distinct that no one ought ever to confuse them.

Formation and locality.—Not uncommon in the lower and middle thirds of the Trenton shales at Minneapolis and St. Paul, Minnesota. Occurs also in the "Lower Blue" at Beloit, Wisconsin.

Genus MONOTRYPA, Nicholson.

Monotrypa (part.), NICHOLSON, 1879, Pal. Tab. Cor., p. 293; 1881, Genus Monticulipora, pp. 102 and 168; ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 153; FOORD, 1883, Contri. Micro-Pal. Can., p. 14.
Monotrypa, ULRICH, 1890. Geol. Surv. Ill., vol. viii, p. 379.
Ptychonema, HALL, 1887. Pal. N. Y., vol. vi, p. xiii.

Zoaria irregularly massive, discoid, or subglobose, apparently not divisible into mature and immature regions. Zoœcia comparatively large, prismatic, with very thin, straight or transversely wrinkled walls; diaphragms complete, remotely placed in the tubes. Both mesopores and acanthopores wanting.

Type: *M. undulata* Nicholson.

We are satisfied that the position of this genus is near *Diplotrypa* (*sensu stricto*) and the simple section of the genus *Batostoma*. In the last we have only the ramose habit of growth, and few and small mesopores and acanthopores to distinguish it from *Monotrypa*, the structure of the walls and the character of all the other points being precisely the same in the two groups. In *Diplotrypa* diaphragms are perhaps always more abundant, but in all other respects, excepting that the tapering proximal ends of the zoœcial tubes are closely tabulated like mesopores, the structure is essentially the same as in *Monotrypa*. There is a largeness and a certain looseness of arrangement that distinguishes the whole family *Diplotrypidæ* from the *Amplexoporidæ*, a family including (under *Leptotrypa*) a number of simple species agreeing otherwise closely with *Monotrypa*. These species of *Leptotrypa* (*e. g. L. filiosa* d'Orb. sp., and *L. petasiformis* Nich. sp.) belong, I am convinced, to a different line of development than that of true *Monotrypa*.

The genus as restricted embraces but few species. Besides the type, which occurs in the Trenton of Canada and New York, we have *M. subglobosa* Ulrich, in the Utica horizon at Cincinnati, *M. rectimuralis* Ulrich, in the Trenton of southern Illinois and probably in the Cincinnati group of Ohio, *M. intabulata*, n. sp., and *M.* (*? Chœtetes*) *cumulata*, n. sp., in the Galena of Minnesota, *M. magna*, n. sp., in the Birdseye limestone of the northwest, *M. colliculata* (*Chœtetes colliculatus* Hall,) in the Lower Helderberg of New York, and *M. tabulata* (*Ptychonema tabulatum* Hall,) in the Upper Helderberg of New York. A small undescribed species occurs in the Niagara of Indiana, while another, apparently belonging here, I found in the Corniferous limestone at Columbus, Ohio.

MONOTRYPA MAGNA, *n. sp.*

PLATE XXVII, FIGS. 28 and 29.

Zoarium growing in large expanded masses, sometimes consisting of superposed layers, the whole perhaps 20 to 40 mm. high and 100 mm. wide; under side generally with a wrinkled epitheca, the upper celluliferous and without monticules. Zoœcia large, polygonal, thin-walled, with clusters of larger size than the average at intervals of about 6 mm., measuring from center to center; about nine in 5 mm.; size of largest in the clusters about 0.8 mm., average diameter of these in the spaces between the clusters about 0.5 mm.

Internal characters: In vertical sections the zoœcial walls are strongly undulating and very thin throughout, and the tubes crossed by complete horizontal diaphragms at intervals varying between one and three times the diameter of a tube. Transverse sections exhibit thin structureless walls, an occasional small (young) cell, and a total absence of mesopores and acanthopores.

The larger size of the zoœcia distinguishes the species from *M. undulata* Nicholson. Excepting the *Crepipora perampla* of the present work, they are larger than in any paleozoic bryozoan known to me. The zoaria of that species are comparatively higher and less expanded, and their zoœcia provided with lunaria.

Formation and locality.—Not uncommon in the "Lower Blue" limestone at Dixon, Illinois; also at Mineral Point and Beloit in Wisconsin. A small fragment from the equivalent limestone at Minneapolis is provisionally identified with it.

Monotrypa intabulata, *n. sp.*

Compare *Monotrypa rectimuralis* Ulrich, 1890, Geol. Sur. Ill., vol. viii, p. 462.

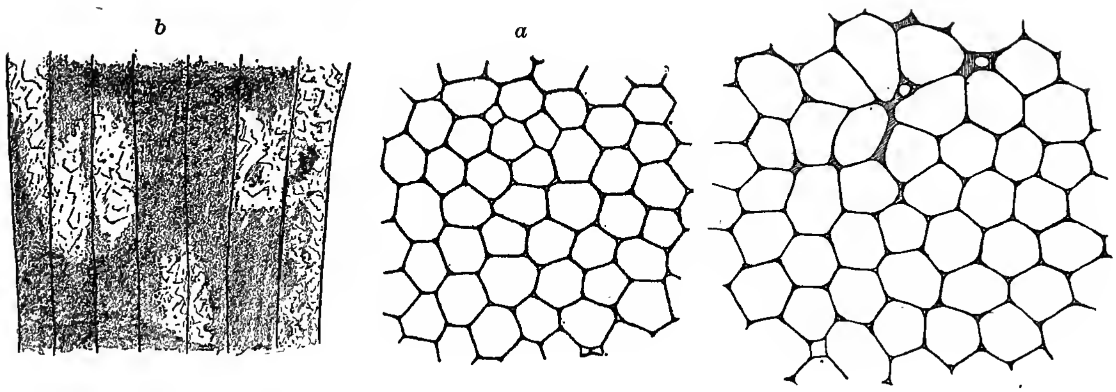


Fig. 20. *Monotrypa intabulata, n. sp.* Upper half of Galena shales, Goodhue and Fillmore counties, Minnesota. Collection of E. O. Ulrich. *a*, transverse section, x18, showing subequal size of tubes, their thin walls, and the lucid spot in the angles of junction; *b*, vertical section, x18, the tubes filled chiefly with clayey matrix; *c*, transverse section, x18, of a variety from Fountain, Minnesota, provisionally referred to this species. It has larger zoœcia than usual, while the size of the latter seems also to be rather less equal.

Zoarium forming subhemispherical or depressed-spherical masses, generally between 30 and 60 mm. in diameter and 15 to 30 mm. in hight; lower surface usually less convex than the upper and sometimes partly covered by an epitheca. Celluliferous surface even, covered with subequal, thin walled, polygonal zoœcial apertures, of which the usual number in 3 mm. is between eight and nine. In several small examples found near Fountain, the number is between seven and eight. Conspicuous and regularly arranged clusters of large cells are wanting, though here and there one or several zoœcia may be of unusual dimensions.

Internal characters: In transverse sections the walls are exceedingly thin, but where well preserved their duplex character is determined by minute triangular, seemingly open spaces at the angles of junction, formed by the separation of the walls of adjoining tubes. Here and there a young zoœcium is met with, but true mesopores and acanthopores as well, are unquestionably wanting. In vertical sections the walls form nearly straight lines (merely curving to adapt themselves to the growth of the zoarium) being entirely without the crenulations so characteristic of the typical species of the genus. Diaphragms also seem to be wanting, and most of the tubes of specimens from shaly strata are in great part filled with the matrix.

At first I believed this species must be the same as the *M. rectimuralis* Ulrich, the types of which were collected from nearly equivalent beds in southern Illinois. The absence of diaphragms was explained by the supposition that they had been destroyed during the process of fossilization. But the study of new material, and other sets of thin sections shows that this explanation is inadequate, since, while the diaphragms are always absent in this form they are present in all associated Bryozoa; and it stands to reason that the conditions under which the two sets of specimens were preserved must necessarily have been identical. I am obliged therefore to consider their absence in the *Monotrypa* as normal, and to give these peculiar Minnesota specimens a new name.

M. intabulata agrees with *M. rectimuralis** not only in the external appearance of the zoarium but in having straight walls and minute triangular open spaces at the angles of junction as well. As differences we have diaphragms two to four times their diameter apart, and rather conspicuous clusters of large cells in the latter and none in the former.

Among associated forms only *Monticulipora grandis* and *Bythotrypa laxata* have a similar growth, the species of *Prasopora* and *Mesotrypa* forming discoidal zoaria. Both of these species however are too widely different structurally from *Monotrypa* to be confounded.

Formation and locality.—Not uncommon in the upper part of the Galena shales (Fusispira beds) at several localities in Goodhue and Fillmore counties, Minnesota.

Mus. Reg. No. 8379.

MONOTRYPA NODOSA, *n. sp.*

(Not Figured.)

Monticulipora (?) *ortoni* WHITFIELD, 1882. Geol. Wis., vol. iv, p. 251. (Not *Chœtetes ortoni* NICHOLSON, 1875. Pal. Ohio, vol. ii, p. 211.)

Zoarium commonly beginning its growth upon shells over and beyond which it spreads till it forms large discoidal or hemispheric masses, often over 5 or 6 cm. in diameter. Sometimes the masses are shapeless, but as a rule the base is concave, and, where it projects beyond the covered shell, clothed with a wrinkled epitheca. Upper surface with more or less prominent subconical monticules, averaging about 3.4 mm. from summit to summit. Zoœcia with thin walls, polygonal and rather regularly arranged apertures, nine or ten in 3 mm.; apertures occupying the monticules but little if at all larger than those in the intermediate spaces. Summits of monticules occasionally appearing solid. Not a trace of either mesopores or acanthopores has been observed. Internal characters unknown, none of the specimens seen being fit for sectioning.

*In the original description of the species I included, erroneously, a hemispheric or lenticular, tuberculated form that is very common in the Hudson river rocks at Savannah, Illinois, and Delafield and Iron Ridge, Wisconsin. As it may justly be expected to occur in the southern part of Minnesota, the next brief description of its known characters may be of advantage to students of the palæontology of the State.

In the absence of any knowledge of the interior the generic position of the species is necessarily a little doubtful. In a general way, *M. nodosa* resembles *Leptrotypa filiosa* d'Orb. sp., of a lower horizon in the Hudson river rocks, very closely, and the principal difference that can now be pointed out is in the size of the zoœcia, that species having eleven or twelve apertures where the present form has nine or ten. But *Atactoporella ortoni* Nich. sp., to which Whitfield referred the Wisconsin specimens, is a delicate parasitic form totally distinct.

Formation and locality.—Common in the upper beds of the Hudson river group at Iron Ridge and Delafield, Wisconsin, and Savannah, Illinois.

Mus. Reg. No. 7574.

MONOTRYPA (? CHÆTETES) CUMULATA, *n. sp.*

PLATE XXVII, FIGS. 26 and 27.

Zoarium forming small subglobular or irregular masses, generally consisting distinctly of irregularly superposed layers; average sizes between 15 and 20 mm. in diameter, anything under or over those extremes being rare; no monticules. Zoœcial walls thin; apertures polygonal, of unequal sizes, sometimes forming at long but irregular intervals large clusters in which they are conspicuously larger than elsewhere; in most cases however the apertures are subequal, with an average of six and one-half or seven in 3 mm. Mesopores and acanthopores wanting.

Internal characters: In vertical sections the tubes diverge rapidly and rather irregularly, and their walls present an obscure longitudinal lineation. Diaphragms occur at intervals varying from one to four times their diameter, but their position in neighboring tubes corresponds approximately. In transverse sections the principal interest attaches to the structure of the walls. In most sections the wall is comparatively thick and seems to be composed of minute columns which, being cut transversely, appear as alternately dark and lighter parts. In this respect the structure of the walls is essentially the same as in true *Chætetes*, and I would unhesitatingly have placed the species into that genus had I been able to satisfy myself that the phenomena observed were not the result of secondary causes. Namely, in some sections the appearance is very different, the wall itself being more sharply defined and thinner than usual (especially where the tubes are filled with matrix instead of calcite) and without the alternating light and dark spots. But where the tubes are filled with calcite the latter for some distance inward from the wall is of a darker color than at the center, and exhibits, strange to say, a spotting not unlike that pertaining to the wall itself in other sections.

The external form, though smaller, is much the same as in *M. intabulata* and other species of the genus, but the zoœcia are larger, and none of them have a wall-structure as described above.

Formation and locality.—Upper part of the Galena shales (Fusispira beds) at various localities in Goodhue county, Minnesota. Also in the Trenton limestone of Canada.

Mus. Reg. Nos. 7629, 7635, 8025.

Family TREMATOPORIDÆ, Ulrich.

For remarks on this family see p. 289.

Genus TREMATOPORA, Hall.

Trematopora, HALL, 1852, Pal. N. Y., vol. ii, p. 149; DYBOWSKI, 1877, Die Chætetiden, p. 69; ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 241; 1883, *idem.*, vol. vi, p. 257; HALL, 1887, Pal. N. Y., vol. vi, p. xiv; ULRICH, 1890, Geol. Surv. Ill., vol. viii, pp. 373, 418.

Not *Trematopora*, ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 153.

Zoaria ramose, branches solid, even or montiferous. Zoœcia with oval or subcircular apertures; surrounded by more or less elevated peristome. Interspaces depressed, sometimes exhibiting the closed mouths of the abundant mesopores. Zoœcial tubes with thin walls and few diaphragms. Mesopores irregularly angular, generally exhibiting an obscurely beaded appearance in vertical sections, with a diaphragm at the constriction. Acanthopores superficial, of moderate or small size, one or more to each zoœcium.

Type: *T. tuberculosa* Hall, Niagara group.

The really essential characters of this genus have been most persistently misinterpreted and overlooked. Even now I am not satisfied that they are fully brought out in the above diagnosis, which is practically the same as the one in volume viii of the Illinois reports. The truth is that more study, especially genealogical, is required before it will be possible to delineate even approximately the limits of the genus. Thus, while almost certain that most of the Lower Silurian species placed here by me (*e. g. T. primigenia* and *T.? nitida*) are not really related to *T. tuberculosa*, I find myself unable as yet to justify their placement elesewhere.

As stated on a preceding page (289) the type of the genus presents many points of agreement with *Batostoma* and is probably to be viewed as a later expression of the same type of structure. Not so, however, with *T.? primigenia* and allied species, these being much more like *Leioclema*, *Bythopora* and *Batostomella*, on the one hand,

and *Nicholsonella* and *Constellaria* on the other. And yet, above all, there are peculiarities that postpone the determination of the systematic position of the next following species till we can learn something of their ancestors. In the meantime they can remain under *Trematopora* and their doubtful affinities be indicated by the usual sign.

As regards *Trematella* and *Orthopora*, two subgeneric names proposed by Hall,* the first is clearly a synonym for *Batostomella*, Ulrich, the second for *Rhombopora*, Meek. Both groups are widely different from true *Trematopora*.

TREMATOPORA? PRIMIGENIA *Ulrich.*

PLATE XXI, FIGS. 23-40.

Trematopora primigenia ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 97.

Zoarium loosely bushy, consisting of small slender ramulets, dividing dichotomously at varying intervals; branches cylindrical or compressed, commonly about 2 mm. in diameter, but varying from 1.5 to 4.0 mm., arising in greater or lesser numbers from a large basal expansion that is thinly spread over some cylindrical body like a crinoid column. Not infrequently the branches inosculate freely. Entire zoaria varying in diameter probably between 20 and 60 mm. Superficial aspect of zoœcia varying with age. In young stages or examples the apertures are more or less oblique, with only the posterior border elevated and the interspaces in a varying degree narrower than the apertures. With age the apertures become somewhat smaller, ovate or subcircular and direct, and the peristome or rim equally elevated all around, while the interspaces were widened till in some examples they are often equal to twice the width of the zoœcial orifices. At the same time the interspaces, which as a rule exhibit no sign of the really very numerous mesopores, are roughened, as are also the peristomes, by the development of acanthopores. These vary greatly in size and number. The arrangement of the zoœcial apertures is only moderately regular, there being here and there spots in which they are of larger size and more widely separated than usual. An average of twelve or thirteen in 3 mm., but the number in that distance may vary from eleven to fifteen.

Internal characters: In vertical sections the tubes have thin walls, are not entirely vertical, and without diaphragms in the axial region. Near the surface they bend outward rather abruptly when one and sometimes two diaphragms were in most cases thrown across each tube. At the same time an abundant series of mesopores was developed. These are crossed by from two to six diaphragms, the

*Pal. N. Y., vol. vi. p. xiv, 1887.

outer ones of which are much thicker and separated by shorter intervals than the inner pair. This gradual thickening of the diaphragms is more decided in the branches than in the basal expansion, part of a vertical section of which is represented in fig. 40. The walls of the mesopores where two or more occupy an interspace are strongly zigzag, in some instances appearing not unlike vesicular tissue. In tangential sections the zoœcial walls may be thin and occasionally even inflected by the acanthopores (fig. 37), but as a rule they are ring-like, as in figs. 38 and 39, and generally completely separated from each other by a series of unequal and irregularly shaped mesopores. The acanthopores are distinct, nearly uniform in size, usually attached to the outer side of the zoœcial walls, and number from one to three or four to each zoœcium.

Var. ORNATA *Ulrich.*

PLATE XXI, FIGS. 26, 28, 33, 34.

Trematopora ornata ULRICH, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., p. 98.

Increased collections have convinced me that this is merely an uncommon variety of *T.? primigenia,* differing from the typical form of the species, as above described, in having the zoœcial apertures a little more elongate and rather more regularly arranged, and in having the peristomes crowned by a crowded row of small papillæ. Larger spines, as shown in fig. 34, are sometimes present.

Var. SPINOSA, *n. var.*

PLATE XXI, FIGS. 29, 30, 35, 36.

Of this form, which, if it proves permanent, should be called a species, I have seen only a few specimens. Though evidently mature they are a trifle smaller than typical *T.? primigenia,* and differ in a number of other minor points from that form. But their principal peculiarity, and the only one that in the present state of our knowedge deserves mention, is the presence of a considerable number of strong spines in the interspaces. A few smaller acanthopores are scattered among the larger ones, but unless searched for they are likely to be overlooked.

The large basal expansion, small branches, rounded zoœcial apertures and depressed interspaces are features that serve to distinguish this species and varieties at once from all associated ramose Bryozoa.

Formation and locality.—The typical form is an abundant fossil in the middle third of the Trenton shales at St. Paul and Minneapolis, while it is not uncommon in the same beds at other localities in the State, notably near Fountain and Preston in Fillmore county. The two varieties are rare and associated with the typical form at St. Paul and vicinity.

Mus. Reg. Nos. 6010, 6011, 7654, 7661.

Genus CONSTELLARIA, Dana.

Constellaria, DANA, 1848, Zoophytes, p. 537; NICHOLSON, 1879, Pal. Tab. Corals, p. 292; 1881, Genus Monticulipora, p. 97; ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 156; 1883, *idem*, vol. vi, p. 265; 1890, Geol. Surv. Ill., vol. viii, pp. 374, 423; JAMES and JAMES, (part.) 1888, Jour. Cin. Soc. Nat. Hist., vol. xi, p. 29.*
Stellipora, DYBOWSKI, 1877. Die Chætetiden d.Ostb. Silur. form., p. 42.

Zoaria subramose or frondescent, growing erect from a basal expansion which is attached to foreign bodies. Surface with stellate maculæ, the spaces between the rays more or less elevated and occupied by two or three short rows or clusters of closely approximated zoœcial apertures. Zoœcia with rather thin walls, small circular apertures enclosed by an elevated rim, equally distributed and partly in contact with each other in the spaces between the maculæ. Interspaces depressed; mesopores abundant, aggregated in the maculæ, always closed at the surface, with gradually crowding horizontal diaphragms. Zoœcial tubes with fewer diaphragms. True acanthopores wanting, but exceedinly minute tubuli, increasing in number with age, are to be detected in the interspaces by means of tangential sections.

Type: *C. florida* Ulrich.

Of this genus I am now acquainted with eight good species and three or four varieties that group themselves around *C. florida*. The earliest known occurs in the Pierce limestone of Tennessee. This is very much like the Minnesota Trenton species next described, but as it has not yet been critically studied it may prove quite distinct. A variety of *C. florida* occurs in the upper Trenton beds at Nashville, Tennessee, and in Canada, and other varieties occur abundantly with the typical form of the species in the lower half of the Cincinnati rocks. *C. fischeri* Ulrich, is a Kentucky form from about the same horizon. In the upper part of the Hudson river group in Ohio, Indiana, Illinois and Wisconsin, we meet with *C. polystomella* Nicholson, and *C. limitaris* Ulrich, and with two undescribed species at Wilmington, Illinois. This locality furnished also the types of *C. parva* Ulrich. These species are all separated easily from each other by means of intelligently prepared thin sections.

CONSTELLARIA VARIA, *n. sp.*

PLATE XXI. FIGS .1-7.

Zoarium consisting of one or more irregularly dividing branches arising from a broad basal expansion. Branches usually compressed, generally from 8 to 10 mm. wide, but varying between the extremes of 3 and 15 mm. Maculæ large, irregularly

*I consider the work of James and James referred to above as unworthy of such quotation, and that its citation among reputable works on the Bryozoa is to dignify it with an attention far beyond its deserts. But the possibility that others may be able to discover merits which I cannot may be sufficient excuse for its inclusion in the bibliography.

stellate, very slightly depressed or on a level with the general plane of the surface. The small clusters of zoœcial apertures (four to ten in each) occupying the angles between the rays may be elevated a little above the level of the maculæ, but as a rule the entire surface may be said to be even. In a few cases however the maculæ themselves are higher than the spaces separating them. Zoœcial apertures subcircular, inclosed by a very thin rim, and varying considerably in size, though approximately equal on each fragment. Width of interspaces varying correspondingly so that about the same number of apertures occur in a given space in all specimens. Ten or eleven occur in 3 mm. in the intermacular spaces, while the diameter of the apertures varies between the extremes of 0.15 and 0.25 mm. Figure 1 represents the surface of a specimen (x9) with small apertures and wide interspaces; fig. 2 a small part of another (x18) having comparatively large zoœcial apertures and correspondingly narrow interspaces. The latter are always a little depressed, and, like the maculæ, occupied by the shallow yet distinct mouths of angular mesopores.

Internal characters: Figure 4 represents a portion of a tangential section where it divides a mature zoarium immediately beneath the surface. In most sections the walls will be thinner and probably not show the minute tubuli in them as drawn in fig. 4. Series of sections prove that the relative width of the zoœcial tubes and interspaces depends largely upon age, the width of the zoœcia decreasing with maturity. Figure 5 is from a good vertical section, and shows that diaphragms occur in all the tubes throughout the zoarium, in the axial region generally about twice their diameter apart, the distance between them becoming less as the zoœcial tubes bend to the surface. In the mesopores, which are very abundant, especially when the section passes through one of the maculæ, the diaphragms are at first rather far apart, but gradually become almost crowded at the surface.

This species is nearer *C. limitaris* Ulrich, of the upper part of the Hudson river group, than any other. The superficial resemblance between them is very decided, but when we compare thin sections we find that the later species has smaller and much more abundantly tabulated mesopores. Indeed, the diaphragms are more numerous in both sets of tubes. All the other described species of the genus have smaller zoœcia, and most of them differ in having no diaphragms in the axial region.

None of the associated species are likely to be confused, none of them having stellate maculæ.

Formation and locality.—Rather rare in the upper beds of the Galena shales near Cannon Falls, Minnesota. It is here associated with *Orthis germana* W and S., *Homotrypa similis* Foord, and several species of *Nematopora.*

Mus. Reg. No. 8044, 8130.

Genus NICHOLSONELLA, *Ulrich.*

Nicholsonella, ULRICH, 1890, Geol. Sur. Ill., vol. viii, pp. 374 and 421.

Zoaria consisting of irregularly intertwining flattened branches or fronds growing from an expanded base; or of laminar, free or parasitic, expansions only. Zoœcial tubes subcylindrical, with diaphragms only moderately numerous; apertures circular, enclosed by a slightly elevated papillose peristome. Interspaces wide, occupied by numerous angular mesopores more or less completely isolating the zoœcia; minutely granulose in fully matured examples. Walls of both sets of tubes thin, and in the peripheral region traversed longitudinally by minute tubuli. With age a perforated calcareous deposit fills the interzoœcial spaces in which the walls of the mesopores become unrecognizable. Mesopores with thicker and generally more numerous diaphragms than the zoœcial tubes. In the axial region of transverse sections of the erect forms the tubes are very unequal.

Type: *N. ponderosa* Ulrich, Geol. Sur. Ill., vol. viii, p. 422, 1890.

This is a Lower Silurian genus with rather uncertain affinities. So far as our knowledge goes the position of the genus in classification seems to be in a measure intermediate between *Constellaria* and *Leioclema.* In another direction we note considerable resemblance to *Heterotrypa.* The type is one of the earliest as well as one of the most complicated and interesting of the *Trepostomata*, and on the whole appears to occupy a rather isolated position with respect to contemporaneous types of structure. It is therefore unfortunate that the preservation of the most typical species of the genus is almost invariably unfavorable for microscopic determination of their internal peculiarities. Indeed, it is a noteworthy fact, that Trenton specimens of *Nicholsonella* are but rarely as well preserved as are associated Bryozoa of other genera.

N. ponderosa was described from the "Lower Blue" or sponge beds at Dixon, Illinois. A nearly related species occurs at Beloit, Wisconsin, and in the middle third of the Trenton shales of Minnesota. Associated with the latter is the laminar species, *N. laminata*, about to be described. *N. pulchra* is a fourth species from the "Pierce" limestone of Tennessee. *N. vaupeli** is abundant in the quarries at Cincinnati, Ohio, as is an undescribed and closely related form occurring higher in the series at several localities in Ohio and Indiana. Finally, *N. cumulata* is described in my Illinois work from the upper beds of the Hudson river group at Wilmington, Illinois.

**Heterotrypa vaupeli* Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., vol. vi. p. 85.

NICHOLSONELLA PULCHRA, *n. sp.*

PLATE XXI. FIGS. 8-12.

Zoarium forming a bushy mass, consisting of irregularly divided, sometimes anastomosing flattened branches, 6 to 10 mm. thick and 8 to 20 mm. wide. Surface with small conical or rounded menticules, subsolid at their apices, and frequently uniting on the rounded edges of the branches to form short ridges. In some specimens the monticules are very slightly developed. Zoœcial apertures rounded, small, subequal, regularly arranged, about eleven in 3 mm., separated by interspaces nearly equalling their diameter—about 0.15 mm. Interspaces minutely papillose, generally depressed midway so that a rather irregular ring of papillæ surrounds each aperture. Mesopores, though completely isolating the zoœcia, are to be detected at the surface only in young and weathered examples.

Internal characters: In vertical sections the tubes diverge with comparative rapidity and uniformity of curvature. Their walls are thin, though not excessively so, and exhibit that lack of sharpness which characterizes especially the Trenton species of the genus. Young zoœcial tubes arise in the axial region mainly and expand very gradually. Diaphragms occur throughout, two or three times their diameter apart in the axial region, and averaging nearly twice as many in a given space in the peripheral region. In young examples it is not easy to distinguish the mesopores from the true zoœcial tubes, but the solid deposit which more or less completely fills up the outer part of the mesopores in the fully matured stages then renders the task an easy one. This deposit is lined vertically with rows of dots, and in many cases is divided up into two or more layers with light intervals between them. The two halves of fig. 10 show, in the upper, the structure of a matured example just beneath the surface. Here the zoœcia are as usual not sharply defined and the interspaces completely filled with solid tissue in which a great number of small dots (representing the superficial papillæ) are to be observed. At a deeper level in the zoarium (see lower half of fig. 10) the large angular mesopores are open. Here even some dots (?acanthopores) are to be made out in the walls, chiefly at the angles of junction.

Transverse sections show that in the axial region the tubes are of all sizes and variously angular. No dots like those seen in tangential sections are to be detected, but one of my sections exhibits fairly conclusive evidence of an intermittent structure of the walls not unlike fig. 26 on plate 27.

There is very little likelihood of confusion between the present species and any other referred to the same genus, and thin sections will of course distinguish it at once from species of other genera. Among the latter *Monticulopora arborea,* from higher rocks, is strikingly like *N. pulchra* superficially.

Formation and locality.—Not uncommon in the "Pierce limestone" at Murfreesboro, Tennessee, where it is associated with an abundance of fossils, chiefly Bryozoa.

Mus. Reg. No. 8131.

NICHOLSONELLA LAMINATA, *n. sp.*

PLATE XXI, FIGS 15-19 and 21.

Zoarium laminar, several mm. thick, the under side strongly wrinkled concentrically. Upper surface even, but exhibiting rather indistinct maculæ or areas in which the interspaces between the zoœcia are wider than usual. Zoœcial apertures circular, regularly arranged, nine or ten in 3 mm., averaging 0.2 mm. in diameter and 0.13 mm. apart. Peristome thin, very minutely papillose. Interspaces occupied by angular mesopores forming a complete series between the zoœcia. Mouths of mesopores closed or open. When closed the interspaces are slightly roughened by small granules among which a few of larger size (? acanthopores) have been detected. Internal characters as shown in figures.

I have taken great pains to illustrate the internal characters just as they appeared to me under the camera lucida, and I refer the student to figs. 15, 16 and 17, rather than attempt a description. I will however admit at once that I do not understand the purpose of the system of dots lining the walls and radiating from the center of one of the zoœcia. The latter may represent perforations in the diaphragms.*

The surface and growth of this species remind one of species of *Fistulipora* with small zoœcia. The laminar form of the zoaria will, it is believed, effectually distinguish it from other forms of *Nicholsonella.* I know of no associated bryozoan with which it might be confounded, and the mere mention of caution should deter the student from carelessly classifying the *Nicholsonella* with the very different discoidal species of *Prasopora* and *Mesotrypa.*

Formation and locality.—Rare in the middle third of the Trenton shales at St. Paul and Minneapolis.

*Such pore-like "dots" and other minute unexplained structures have been drawn carefully on a number of the plates attached to this work. Some day perhaps we may be able to appreciate their significance. In the meantime we must gather *facts* and I shall continue to delineate them as faithfully as I can. In this connection it may be well to mention what many microscopists have long observed with dismay. Namely, that minute structures like those in question are gradually obliterated by some insidious action of the Canada balsam in which the preparations are mounted. It is therefore desirable, indeed necessary, to make the drawings as soon as possible after mounting the sections.

NICHOLSONELLA PONDEROSA ? *Ulrich.*

PLATE XXI, FIGS. 13, 14, 20 and 22.

?*Nicholsonella ponderosa* ULRICH, 1890. Geol. Sur. Ill., vol. viii, p. 422, pl. XXXIV, figs. 5-5*d*.

Two specimens only of this form were found by the author at Minneapolis in the lower third or "Stictoporella beds" of the Trenton shales. One is an irregular mass, 65 mm. long by 30 to 40 mm. in thickness, presenting the bases of several large branches. The surface is not well preserved, but seems to have been considerably like that of *N. laminata.* The interior likewise is but illy preserved, and the illustrations (figs. 13 and 20) may be objected to on the ground that they are much more distinct than the sections. The "dots" in the interspaces have most probably been drawn too small and too numerous. It seems that two or three should have been united into one, giving an appearance more like fig. 10 of the same plate. Still, enough of the internal characters are to be made out to render the generic reference almost beyond dispute. On protected spots the surface is decidedly spinulose. Here about nine zoœcial apertures occur in 3 mm.

The other specimen is a fragment of a branch, about 11 mm. thick and 14 to 19 mm. wide. In the shape of the zoœcia, their number in a given space, and in the charcter of the interspaces and interior, this specimen is apparently precisely like the first.

There is nothing decidedly opposing the placing of these specimens with *N. ponderosa,* the types of which are from the sponge-layer of the "Lower Blue" limestone at Dixon, Illinois. Still, better preserved material is desirable before much confidence is to be placed in the identification.

Family AMPLEXOPORIDÆ, Ulrich.

Genus LEPTOTRYPA, Ulrich.

Zoaria varying from thin incrustations to free forms of discoidal, spiral, or elongate conical shape; subglobose and irregularly massive species occur also. Zoœcial tubes polygonal, with thin walls just appreciably thickened in the mature regions, and a variable number of diaphragms. Acanthopores small, more or less numerous, but almost invariably restricted to the angles of junction between the zoœcial tubes. Mesopores wanting.

Type: *L. minima* Ulrich, of the Cincinnati group.

This genus includes forms essentially like those of *Amplexopora,* Ulrich, only they arise into erect branching zoaria while the species of *Leptotrypa* never depart from the types of growth mentioned in the description. Numerous species of both genera are known and several of *Leptotrypa* from the Trenton beds of Minnesota. True *Amplexopora*, however, is first met with in the Utica.*

LEPTOTRYPA HEXAGONALIS *Ulrich.*

(Not Figured.)

Leptotrypa hexagonalis, ULRICH, 1890. Geol. Surv. Ill., vol. viii, p. 455.

Original description: "Zoarium forming parasitic expansions less than 1 mm. in thickness, spread upon *Orthoceras* and *Hyolithes*. Surface smooth. Clusters of cell apertures of almost twice the usual size are arranged in diagonally intersecting rows; these clusters are about 3 mm. apart, measuring from center to center. Zoœcia regularly hexagonal in shape, sometimes a little elongated, seven, measuring longitudinally, almost nine, diagonally, in 2 mm.; diameter of the smaller 0.2, of the larger 0.35 mm. Acanthopores prominent on the surface when well preserved."

This species occurs almost invariably as a delicate lace-like expansion upon *Hyolithes baconi* Whitfield. This fact, together with the markedly hexagonal shape of the zoœcial apertures, renders it an easily recognized species.

Formation and locality.—Rather rare in the limestone at Minneapolis, Minnesota. The types are from equivalent beds ("Lower Blue") at Mineral Point, Wisconsin, and Calhoun county, Illinois. Other localities are Janesville and Beloit, Wisconsin.

Mus. Reg. Nos. 7551, 7557, 7595.

LEPTOTRYPA INFORMIS, *n. sp.*

PLATE XXVII, FIGS. 22 and 23.

Zoarium forming parasitic patches or lump-like growths upon foreign bodies, varying considerably in size and from 1 to 5 mm. in thickness. At other times apparently free, with a wrinkled epitheca beneath. Surface without monticules, nor are the clusters of large cells very conspicuous except in a few cases where the zoœcia forming them are separated by a limited number of small cells. Zoœcial apertures polygonal, thirteen or fourteen of the average size in 3 mm. Walls very thin, in vertical sections sometimes appearing as though made up of alternating horizontal bands of light and dark shades. Acanthopores more or less prominent at the surface, varying some in size, restricted to the angles of junction, one-half of which are occupied by them. Diaphragms complete, on the whole rather remote and irregularly distributed, the intervals between them varying from one to four times their diameter.

*Trenton species have been placed under *Amplexopora* by both Mr. A. H. Foord and myself, but a re-examination has convinced me that the species in question are more likely aberrant types of *Batostoma*, where I would now place them.

In many respects like *L. semipilaris* Ulrich, of the Cincinnati rocks, the most striking difference appearing in the number of the diaphragms, these being almost totally absent in that species. An undescribed species, differing chiefly in having much smaller and fewer acanthopores, occurs in the Galena shales.

Formation and locality.—In the lower and perhaps also in the middle third of the Trenton shales at Minneapolis and St. Paul.

Mus. Reg. No. 6024.

LEPTOTRYPA ACERVULOSA, *n. sp.*

PLATE XXVII, FIGS. 24 and 25.

Zoarium occurring as small, irregular or subglobular masses, generally between 15 and 20 mm. in diameter and somewhat less in hight. Surface approximately even, but clusters of cells are conspicuously larger than the average, and in one case these are elevated into low monticlues. Zoœcia angular, thin-walled, thirteen to fifteen, commonly fourteen of the usual size in 3 mm.; average diameter of apertures in the spaces between the clusters about 0.21 mm., of the largest in the clusters 0.35 to 0.4 mm. New tubes are interpolated in a great measure at corresponding levels through the zoarium, so that immediately above and beneath such a level there may be considerable difference in the average size of the tubes. Diaphragms from one to one and a half times their length apart except in the mature regions where they are separated by intervals about half as long. Acanthopores very small, in the angles, developed at intervals only, no trace of them being visible in some of the transverse sections. At the surface they are but rarely to be distinguished. In a single example, however, many of the angles of junction are prominent and the walls between them crowned with a closely arranged row of minute papillæ.

L. acervulosa agrees in most respects very closely with an undescribed species occurring at Clarksville, Ohio, in the upper beds of the Hudson river group. Smooth examples of *L.* (*Monotrypa*) *irregularis* Ulrich, also from Ohio, are likewise simulated, but that species is distinguished by having tubes practically without diaphragms. Two other species from the Cincinnati exposures, *L. filiosa* d'Orb., sp. and *L. petasiformis* Nich., sp., are probably the nearest among described species. The first grows in large masses and has well developed monticules, while the second forms hat-shaped or hemispheric zoaria like *Prasopora simulatrix.*

Formation and locality.—Not uncommon in the Galena shales at Decorah, Iowa. A single specimen from the same horizon in Goodhue county, Minnesota. Also in the shaly part of the Trenton at Burgin and Frankfort, Kentucky.

Mus. Reg. No. 8060.

Leptotrypa claviformis, *n. sp.*

PLATE XXVII, FIGS. 20 and 21.

Zoarium growing around and beyond one or more segments of *Arthroclema* and *Helopora* into simple club-shaped forms varying from the smallest figured to one that is 23 mm. long and 1.5 to 2.5 mm. in diameter. Some of the specimens have one or two short lateral branches, in which cases the supporting body was a twig of *Arthroclema* with lateral segments in place. Zoœcial tubes growing about the axial body very much as in ordinary ramose forms they grow about an imaginary center; diaphragms abundant except in the outer or direct portion; walls thin. Zoœcial apertures subangular, nearly uniform in size, there being no *appreciable* clusters of large cells; without apparent arrangement, about fourteen in 3 mm. What may be mesopores, but more likely are merely young zoœcia, are scattered among the ordinary tubes. At intervals, however, they seem to be more numerous than usual. Many, perhaps the majority, of the angles of junction are thickened and occupied by projecting acanthopores.

In a general way, this species may be said to fall under *Leptotrypa*, but I am more than inclined to doubt that it belongs there. The interior of the specimens sectioned is but illy preserved, the finer details of structure being quite obscure. Some of the specimens remind of *Petigopora*, Ulrich, and it is here that better sections will probably cause us to refer them.

Formation and locality.—Rather common in the middle and upper thirds of the Trenton shales at St. Paul and Minneapolis.

Mus. Reg. No. 8132.

Family CERAMOPORIDÆ, Ulrich.

Genus SPATIOPORA, Ulrich.

Spatiopora, Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 155, and 1883, vol. vi, p. 166; Foord, 1883, Contri. Micro-Pal. Cambro-Sil. Rocks, Can., p. 20; Ulrich, 1890, Geol. Surv. Ill., vol. viii, p. 381.

Zoaria forming thin parasitic crusts upon foreign bodies, the shells of *Orthoceras* being the most favored. Surface even or with monticules. Zoœcia short, with direct and more or less irregularly shaped apertures. Lunarium scarcely perceptible even in thin sections. Mesopores very few, usually absent, when present occurring chiefly as "maculæ." Interspaces often with large blunt spines (? acanthopores). Walls of zoœcia moderately thin, with the characteristic structure pertaining to the family.

Type: *S. aspera* Ulrich.

Two Trenton species, *S. areolata* Foord, and *S. labeculosa* Ulrich, are referred to the genus with doubt.* The type, together with four or five other species, is found in the Cincinnati or Utica and Hudson river groups, above which the genus is not known to pass.

SPATIOPORA LABECULOSA, *n. sp.*

PLATE XXVIII, FIGS. 1 and 2.

Zoarium forming large and very thin expansions generally upon *Orthoceras* or *Endoceras.* Surface even, but conforming with the irregularities of the body grown upon. At intervals of 4 or 5 mm., measuring from center to center, there are clusters of cells decidedly larger than the average. These large apertures—they vary from 0.25 to 0.50 mm. in diameter—are arranged in each case about a sub-stellate or irregular, apparently solid, spot, which on closer examination proves to consist of closed mesopores. The extent of these spots varies greatly, some being almost 2 mm. wide, while in others the center is scarcely more than 0.5 mm. wide. Zoœcial apertures subangular, usually a little oblong, with the margin on one side generally a little higher and more rounded than on the other. The last is true more particularly of the large cells which are not infrequently decidedly oblique and directed away from the center of the maculæ. In very young examples all of the apertures may be quite as oblique as in some species of *Ceramoporella*, but the lunarium is ever an inconspicuous feature. Many of the large cells again may preserve peculiar convex closures. Of the smaller or average zoœcia eleven to thirteen occur in 3 mm. Mesopores varying in number and distribution, but something like the following rule seems to prevail. When the maculæ are large the mesoposes are few and of small size elsewhere (see figs. 1 and 2); when small they are comparatively more abundant in the inter-macular spaces.

Internal characters: Figure 2 is a faithful copy of a portion of a tangential section prepared from a specimen (fig. 1 is an enlargement of its surface) having large maculæ. It will be noticed that the side of the zoœcia nearest the macula is nearly always less angular than the opposite side. This fact is good evidence of the possession of an incipient or undeveloped lunarium. The minute structure of the walls, which is not the same as in *Leptotrypa*, is likewise indicative of ceramoporoid affinities. In vertical sections the prostrate part of the tubes is rather short, and the erect part, forming an angle of about 80° with the line of the surface, perhaps

*Since this report was placed in the hands of the printer, two specimens of a typical species of this genus were collected by the author in the upper part of the middle third of the Trenton shales at Chatfield, Minn. The specific characters of these specimens, which grew over the shells of a small *Orthoceras*, are very similar to those of *S. maculosa* and *S. lineata* Ulrich, of the Cincinnati rocks, As a provisional designation for the form I would propose the name *S. maculosa*, var. *incepta*.

never exceeds 1 mm. Diaphragms are wanting in most of the tubes, but here and there the sections pass through one or several adjoining tubes having one diaphragm about midway up and sometimes another at the mouth.

This is an interesting and easily recognized species. Of associated parasitic forms only two need be compared; one, *Stromatotrypa ovalis* of this work, has oval and much larger zoœcia; the other is a rare and as yet undetermined form with circular and smaller zoœcia, numerous mesopores, and more uneven zoarium. *S. labeculosa* differs from both in the greater size and distinctness of its maculæ, and in the slight obliquity of its zoœcial apertures. The maculæ will distinguish the species at once from all the other species of the genus.

Formation and locality.—In the middle third of the Trenton shales at Minneapolis and St. Paul.

Mus. Reg. No. 5026.

Spatiopora iowensis, *n. sp.*

(Not figured.)

Zoarium spread as an exceedingly thin crust over the cones of *Orthoceras sociale* Hall. Monticules wanting, but unusually distinct clusters of large cells are distributed over the surface at intervals of about 5 mm., measuring from center to center. Zoœcia larger than in other species of the genus, their walls thin, the apertures nearly or quite direct, angular, often of hexagonal or rhombic shapes, with three of those in the clusters in 2 mm. and an average of nine of those in the spaces between the clusters in 3 mm. Mesopores wanting except in the clusters mentioned where a few may be wedged in among the large cells. Many of the angles of junction between the apertures are raised into sometimes small, at other times large, acanthopore-like prominences.

In the dark shales at Graf, Iowa, this bryozoan is preserved as a thin gladiolus leaf-like film, the *Orthoceras* grown upon being compressed to such a degree that its original presence may not be suspected.

This species is in every respect a true *Spatiopora.* The affinities are nearer *S. maculosa* Ulrich, of the Cincinnati rocks, than to any of the others, and it is with that species that I first thought to place it. On comparison however *S. iowensis* proved to have larger zoœcia, with eight to ten where the Ohio species has eleven or twelve.

Formation and locality.—Maquoketa shales of the Hudson River group at Graf, Iowa.

Mus. Reg. Nos. 7586, 7587.

Genus CREPIPORA, Ulrich.

Crepipora, ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 157; 1890, Geol. Surv. Ill., vol. viii, pp. 380, 469.

Zoaria incrusting, massive, or hemispherical; in one case forming regular hollow branches. Surface, especially in the first and last styles of growth, exhibiting at regular intervals maculæ of mesopores, appearing as minutely porous or subsolid elevations or depressions. In the massive forms these maculæ, to which the mesopores are usually restricted, are very small. Zoœcial tubes erect, their apertures very slightly oblique and varying from rhomboidal to subpyriform in shape. Lunarium small and easily overlooked except in well preserved examples; best shown in tangential sections. Thin diaphragms are developed in moderate numbers.

Type: *C. simulans* Ulrich.

Eleven or twelve species, several as yet undescribed, are known to me having the characters ascribed to this genus. Three of these are Trenton, the rest, save an Upper Silurian species from Gotland, are Utica or Hudson River group forms.

Crepipora differs from *Ceramporella* in having much fewer mesopores (typically none) in the inter-macular spaces, longer tubes, and less oblique apertures. *C. epidermata* Ulrich, from the Hudson River group of Illinois, is closely related to the new genus *Bythotrypa*, and ought perhaps to be referred to that genus, but it has seemed the wiser course to leave the species as originally described until special investigations into the inter-relations of the *Ceramoporidæ* can be taken up.

CREPIPORA SUBÆQUATA, *n. sp.*

PLATE XXVIII, FIGS. 26-28.

Zoarium a small laminar or incrusting expansion, 1 to 3 mm. thick. Zoœcial apertures approximately direct, angular, often quadrate or pentagonal, of nearly uniform sizes on all parts of the surface, no distinguishable clusters of cells larger than the average having been developed; ten in 3 mm. Lunarium very slightly developed, the zoœcial apertures and walls appearing much more like those of species of *Monotrypa* than of a ceramoporoid. Tangential sections, however, (see figs. 26 and 27) afford more or less clear evidence of its presence, but it is rare to find more than one of the ends of the lunarium projecting inward from the wall. Many of the angles of junction are thickened and include an acanthopore-like structure.

Mesopores very few. In vertical sections the walls are thin, with faint transverse lineation, and somewhat irregular. Diaphragms occur sparingly and at unequal intervals in the zoœcial tubes, but in the mesopores which, being few, are not often seen, they are numerous.

The absence of clusters of large cells and the greater average size of the ordinary zoœcia will distinguish this peculiar species from associated Bryozoa having a similar mode of growth.

Formation and locality.—Rare in the upper third of the Trenton shales at St. Paul, Minnesota.

Crepipora spatiosa, *n. sp.*

(Not figured.)

This name is proposed for a massive or heavy lamellate form that occurs in the Bryozoa layers at the top of the Trenton near Harrodsburg and Frankfort, Kentucky. It is closely related to *C. hemispherica* Ulrich (upper beds of Hudson River group in Illinois), on the one side, and *C. perampla* on the other. From the first it differs in the greater size and different shape of its zoarium, in having thinner walls and fewer diaphragms, and less distinct lunarium. The second has larger zoœcia and even less developed lunarium, but in other respects is very similar to the Kentucky species.

Specimens of this species may attain a diameter of 300 mm. with a thickness of from 50 to 100 mm. Of the ordinary zoœcia twelve occur in 5 mm. Diaphragms 0.4 to 1.0 mm. apart.

Crepipora perampla, *n. sp.*

PLATE XXVIII, FIGS. 29-32.

Three specimens have been seen of this. One, about 70 mm. in diameter and 33 high, is hemispheric, with the base concave and the margin flaring slightly. The others are larger (about 95 mm. in diameter) and, though worn, the basal part of the zoarium seems to have been convex instead of concave. Zoœcia large, with very thin walls, generally of angular shapes, the pentagonal and hexagonal more common than the subrhomboidal; those of the average size about 0.5 mm. in diameter, with nine or ten in 5 mm. At intervals of 5 or 6 mm. clusters of tubes of more or less decidedly larger size than the ordinary are to be observed. Some of these may attain a width of 0.9 mm., but as a rule their size varies between 0.6 and 0.8 mm. Mesopores very few.

The appearance of thin sections is shown in the figures on plate XXVIII. In figs. 30 and 31 the presence of the lunarium is shown in an unmistakable manner, but fig. 32 is more like the usual appearance. Indeed, the lunarium is often so difficult to distinguish in transverse sections, that it is in order to caution the student against confusing the species with *Monotrypa*. In vertical sections the walls are often minutely crenulated, and in most cases exhibit the transverse lineation so common among the ceramoporoids. Exceedingly thin diaphragms occur in all the tubes at intervals varying from one to two tube-diameters.

The great size of the zoœcial tubes separates this species from all the other forms of *Crepipora* known. In this respect the species is approached by but one other paleozoic bryozoan, the *Monotrypa magna* of the present work, and both are believed to occur in nearly the same geological horizon. These two forms also present some points of resemblance in vertical sections, but so far as I can see there is really no relationship between them. In the *Monotrypa* the zoœcia are much more regularly angular, their walls without the transverse lineation and more coarsely wavy, while a lunarium is of course never present. The *C. hemispherica* Ulrich, which seems to occur in the shales of the Hudson River group at Granger and near Spring Valley, differs chiefly in the smaller size of the zoœcial tubes.

Formation and locality.—Trenton limestone at Chatfield and two miles northeast of Spring Valley, Minnesota.

Mus. Reg. Nos. 151, 170, 211.

Genus BYTHOTRYPA, n. gen.

Zoaria massive or lamellate. Zoœcia forming long continuous tubes, intersected by thin diaphragms, their walls minutely crenulate and with the structure characterizing the ceramoporoids. Lunarium well defined, large, projecting above the rest of the aperture margin. Mesopores numerous, open at the surface, interiorly forming a species of vesicular tissue unusually loose and irregular in construction.

Type: *Fistulipora laxata* Ulrich.

Largely increased collections of the type of this genus have convinced me that the species really belongs to the *Ceramoporidæ*. As none of the established genera of that family would include it, a new generic division became necessary. *Bythotrypa* is probably, as I regarded it at first, a type of structure that culminated in true *Fistuliporidæ*, but the lines along which the development progressed we are as yet unable to define. Still, it is more than possible that we have here merely a foreshadowing of that family—in other words, a premature evolution of the fistuliporoid type—that became extinct or was reabsorbed into the parent stock, failing to establish a permanent line of development. In that case *Crepipora? epidermata* Ulrich, from the Hudson River rocks of Illinois, would seem to be the earliest known point in the direct line to *Fistulipora*.

BYTHOTRYPA LAXATA *Ulrich.*

PLATE XXVIII, FIGS. 21-25.

Fistulipora? laxata ULRICH, 1889. Contri. Micro-Pal. Cambro-Sil. Rocks, Can., pt. ii, p. 37.

Zoarium irregularly massive, usually beginning its growth upon some foreign body, the exposed under side strongly wrinkled and covered with an epithecal membrane. Specimens vary greatly in size, the smallest seen being about 12 mm. in diameter and 5 mm. or less high, while the largest is an oval mass 150 mm. long, 120 mm. wide, and about 70 mm. high. In the lower third of the Trenton shales they are all small, none observed exceeding 50 mm. in diameter. In the middle and upper thirds specimens between 75 and 100 mm. wide are not rare, but masses exceeding that size have been met with only in the upper part of the Galena shales.

Zoœcial apertures subovate, nearly equal, direct or a little oblique, the lunarium broad, sharply elevated, sometimes seeming to arch slightly over the aperture; their arrangement appearing more irregular than it is, with nine or ten in 5 mm. Mesopores abundant, varying greatly in size, a few quite as large as the zoœcia from which they are distinguished by their more angular and irregular form and in being without a lunarium. Mesopores forming larger or smaller clusters at irregular intervals from which the zoœcial apertures are turned in a radial manner. These clusters are most inconspicuous—even difficult to make out under the glass—except under certain conditions of weathering when they stand out as subsolid spots. Under ordinary circumstances the whole surface seems to be occupied uniformly by an irregular network of cells.

Internal characters: In transverse sections the appearance, aside from an unusual irregularity and looseness of arrangement, is much as in species of *Fistulipora*. The zoœcia are irregularly pyriform or ovate in cross section, and have thin walls. The lunarium, though often not a very marked feature, is still always determinable by the more regularly curved semi-circular form of the lunarial side of the circumference of the zoœcium, the opposite side being, if not angular, at any rate always drawn to a circle of greater diameter than the lunarial side. Occasionally one or both ends of the lunarium may project into the zoœcial cavity (see fig. 25). Not infrequently also the lunarial side is thickened by a light-colored deposit upon the outer side in which very fine transverse lines may be noticed. Dimensions of zoœcium of average size, about 0.3 by 0.4 mm. Interstitial cells varying greatly in size and distribution, some being very small, others as large and even larger than the zoœcia. They form generally but a single series between the zoœcia, yet it is not uncommon to notice a double row for a short distance. An obscure radial arrangement, with the zoœcia in contact lengthwise, is noticeable about certain points, 6 mm. or more apart, where the interstitial cells are more numerous than elsewhere, without, however, at any time being in sufficient numbers to justify being called "maculæ."

Vertical sections are even more characteristic, since in these the *loose construction* mentioned is very striking. The zoœcia appear as long irregular tubes crossed at variable intervals by exceedingly delicate horizontal diaphragms. The average distance between the diaphragms depends somewhat upon the horizon from which the specimen was collected. In zoaria from the lower and middle thirds of the Trenton shales, the average is between 0.5 and 0.9 mm., but in those from the Galena shales it is between 0.8 and 1.2 mm. The interstitial cells assume all sorts of shapes, but are always extremely high. A tendency to arrange themselves in vertical series is usually manifest, but they cannot be said to form tabulated tubes, their walls being on the whole quite irregular and the end partitions more or less oblique and in many cases overlapping. All the walls have that peculiar granular structure noticed, in paleozoic Bryozoa, only among the *Ceramoporidæ* and *Fistuliporidæ.*

Both the external and internal characters of this species are so distinctive that there is little or no danger of confusing it with associate massive forms.

Formation and locality.—Not rare in the three divisions of the Trenton shales at Minneapolis, St. Paul and Cannon Falls. It reappears, larger than ever, in the upper part of the Galena shales at several localities in Goodhue county, Minnesota, and at Decorah, Iowa. The original Manitoba type of the species I now believe to have come from strata equivalent to the last. It was collected at St. Andrews.

Mus. Reg. Nos. 5963, 7602.

Genus ANOLOTICHIA, Ulrich.

Anolotichia, Ulrich, 1890. Geol. Sur. Ill., vol. viii, pp. 381 and 473.

Zoaria large, irregularly ramose or digitate. Zoœcia comparatively large, forming long prismatic tubes, intersected by complete diaphragms more or less remotely situated. Walls thin, appearing transversely lineate in vertical sections. Apertures angular or subovate, direct, with a distinctly elevated lunarium. Thin sections show the lunarium to be traversed lengthwise by from two to seven minute, closely tabulated tubes. Mesopores very few in *A. impolita*, but moderately abundant, rather equally distributed among the zoœcia, and of irregular form, in the type species.

Type: *A. ponderosa* Ulrich, Hudson River group, Wilmington, Illinois.

Only two species, the type and the one next described, are as yet known of this remarkable genus. Aside from the lunarial tubuli, which constitute the principal distinctive character, the genus corresponds rather closely on the one hand, through *A. impolita*, with *Crepipora*, and fully as well on the other, through *A. ponderosa* with *Chiloporella*. In the absence of any positive knowledge concerning the functions and classificatory value of the lunarial tubuli, the relationships noted must provisionally determine the systematic position of *Anolotichia* as intermediate between those genera.

Anolotichia impolita *Ulrich.*

PLATE XXVIII, FIGS. 15-20.

Crepipora impolita Ulrich, 1886. Fourteenth Ann. Rep. Geol. Nat. Hist. Sur. Minn., p. 77.

Zoarium large, bushy, consisting of abundantly and irregularly divided solid branches, the latter varying from 5 to over 20 mm. in diameter. At the base the branches may coalesce, and here they are always stronger than at their terminations. Rarely the zoarium is not branched but occurs as an irregular mass with lobe-like excrescences. Zoœcia large, with moderately thin walls, direct, hexagonal or subrhomboidal apertures. The latter are subequal (there being no distinguishable clusters of large ones), are arranged in rather regular series with eleven in 5 mm. Lunarium well developed, appearing as a small crescentic elevation usually in one of the angles. Mesopores few, sometimes appearing to be absent entirely; occasionally forming small clusters of from two to six.

Internal characters: In tangential sections the walls of contiguous zoœcia appear to be thoroughly amalgamated; the lunarium is represented by two or three small lucid spots (lunarial tubuli) on one side of the tube, the end ones projecting slightly into its cavity. In vertical sections the tubes are scarcely to be called vertical even in the axial region, curving outward with a uniform curve from the beginning. Their walls are composed of rapidly alternating dark and lighter shades of schlerenchyma, so that they appear more or less distinctly lineate transversely. The cause of these lines, which are closest in the peripheral part of the zoarium, is unknown, unless the light ones, which are of uniform width and, especially in the axial region, narrower than the dark bands, represent rows of perforations. Exceedingly delicate diaphragms, their diameter or more apart, occur chiefly in the outer and middle parts of the tubes. The axial portion of transverse sections is very nearly like tangential, the only difference being that the walls are a little thinner and small tubes comparatively more abundant.

The much smaller number of mesopores is the most obvious external difference between the present species and *A. ponderosa* Ulrich. The lunarial tubuli also are about twice as numerous in that species. Of Minnesota species, I know of only one that is likely to be confounded. This is the *Batostoma magnopora*, a rare species of the middle third of the shales (Rhinidictya beds), having, if not always monticules, at least conspicuous clusters of large cells. The absence of such clusters in the *Anolotichia* renders the separation of the two forms comparatively easy after all.

Formation and locality.—This is a very abundant and highly characteristic fossil of the lower third of the Trenton shales at St. Paul, Minneapolis, Cannon Falls, Chatfield, Lanesboro and Fountain.

Mus. Reg. Nos. 5958, 5962, 7660.

Genus CERAMOPORELLA, Ulrich.

Ceramoporella, ULRICH, 1882, Jour. Cin. Soc. Nat. Hist., vol. v, p. 156; Geol. Surv. Ill., vol. viii, pp. 380, 464.

Zoaria incrusting, often becoming massive by the superposition of numerous thin layers. Zoœcial tubes short, their walls thin. Apertures more or less oblique, hooded, commonly of oval shape. The hoods are directed away from the centers of small maculæ marking the surface at rythmical intervals. Mesopores abundant, often completely isolating the zoœcia, their apertures usually open, sometimes closed by a thin membrane. Diaphragms only rarely present.

Type: *C. distincta* Ulrich, Cincinnati group, Ohio.

This genus embraces all the parasitic Lower Silurian ceramoporoids. The species, with few exceptions, are all closely related, and some of them seem also to have an unusually extended vertical range. Thus the first of the following Minnesota species, which occurs here in the lowest member of the shales, is so much like the Cincinnati types of the genus that I cannot distinguish them. *C. inclusa* is a well marked species, and unknown above the upper third of the Trenton shales, but the Galena shales species, *C. interporosa*, n. sp., is likewise a common form throughout the lower 300 feet of the rocks at Cincinnati, Ohio.

CERAMOPORELLA DISTINCTA *Ulrich.*

PLATE XXVIII, FIG. 13.

Ceramoporella distincta ULRICH, 1890. Geol. Surv. Ill., vol. viii, p. 464.

Zoarium forming thin parasitic patches upon other Bryozoa, the Minnesota specimens seen consisting of but a single layer less than 0.7 mm. thick. Zoœcia small, radially arranged about certain small maculæ, nine to eleven, measuring obliquely, in 3 mm. Apertures very oblique, with an overhanging hood, highest posteriorly. Mesopores numerous, small, usually forming a single linear series between the sides of the zoœcia.

This species is much rarer than the associated *C. inclusa* from which it is at once distinguished by its smaller and differently shaped zoœcial apertures. In *C. interporosa* the apertures are larger and more direct.

Formation and locality.—Lower third of the Trenton shales at Minneapolis and St. Paul. It is met with next in the Cincinnati rocks, being an abundant species at that locality.

CERAMOPORELLA INCLUSA, *n. sp.*

PLATE XXVIII, FIGS. 8-11.

Zoarium forming thin crusts over foreign bodies, not observed to consist of more than a single layer, less than 1 mm. thick, generally 20 mm. or more in diameter. The customary maculæ, about which the zoœcial apertures are arranged in a radial manner, are represented, but less distinctly than usual. Nor is the radial disposition of the apertures as marked a feature as usual. Indeed, it is common to find, as shown in figure 8, all of them turned toward the nearest margin of the zoarium. Zoœcial apertures oval, occupying, with three mesopores, the bottom of subtriangular or rhomboidal, obliquely depressed spaces. One of these mesopore-pits is in front, the second and third on the sides of the true aperture, the posterior side of the latter being formed by the strongly elevated lunarium which in this species is an unusually prominent feature. Arrangement of apertures only moderately regular, eight or nine in 3 mm.

Numerous deviations from the above described normal characters of this species are shown in the abundant material before me. Most of them are due to imperfect preservation and irregularities of growth, and all of them are of a nature that can be interpreted successfully only by extended study of specimens.

The inclusion of each zoœcial aperture and mesopores in a subtriangular enclosed space, and the strong development of the lunarium are distinctive for the species. These features are less constant in what I presume to be a mutation of the species (toward the Cincinnati group *C. ohioensis* Nicholson) occurring in the upper third of the Trenton shales.

Formation and locality.—Common in the lower and middle thirds of the Trenton shales at Minneapolis, St. Paul, and various localities in Goodhue and Fillmore counties. Rare and less typical in the upper third of the shales at St. Paul and Cannon Falls.

Mus. Reg. Nos. 7624, 7656, 7661, 7662, 8380.

Ceramoporella interporosa, *n. sp.*

PLATE, XXVIII, FIG. 12.

All the Minnesota examples seen are thin crusts upon foreign bodies, but in the Cincinnati rocks the species often forms large masses by superposition of numerous layers. The zoœcial apertures are larger, more direct, and comparatively wider than in *C. distincta* Ulrich, with an average of nine in 3 mm. Fig. 12 represents the usual appearance of the surface. Sometimes the lunarium is better distinguished from the rest of the posterior hood than shown in the figure. The mesopores are always numerous and generally more equally distributed around the zoœcia than in other species of the genus.

Formation and locality.—In Minnesota the species has been noticed only in the Galena shales of Goodhue county. At Cincinnati, Ohio, the same species apparently is not uncommon in the lower 300 feet of strata.

Mus. Reg. No. 7647.

Genus DIAMESOPORA, Hall.

Diamesopera, HALL, 1852, Pal. N. Y., vol. ii, p. 158 (not defined); Pal. N. Y., vol. vi, p. xv, 1887; ULRICH, 1890, Geol. Surv. Ill., vol. viii, pp, 380, 467.
Cœloclema, ULRICH, 1882. Jour. Cin. Soc. Nat. Hist., vol. v (not defined).

Zoaria ramose, branches hollow, lined internally with a striated epitheca. In other respects very much like *Ceramoporella* and *Ceramophylla*.

This name stands for an easily recognized division of the *Ceramoporidæ*. The genus may be more convenient than natural, yet I must confess that the evidence so far gathered points rather to an opposite conclusion. The species next described is the earliest known. Several occur in the Cincinnati rocks, but it is not till we come to the Niagara that the genus has its greatest development, both in the way of species and individuals.

Diamesopora trentonensis, *n. sp.*

PLATE XXVIII, FIG. 14.

Zoarium consisting of small hollow branches varying from 1.5 to 3.5 mm. in diameter; thickness of zoarium 0.4 to 0.8 mm.; axial tube varying in diameter, the epithecal lining not observed. Small maculæ sometimes present. Zoœcial apertures oval, about their diameters apart, arranged sometimes regularly in diagonally intersecting rows, at other times as shown in fig. 14; averaging nine in 3 mm. When regularly arranged they are set into obliquely depressed subrhomboidal areas, reminding of *Ceramoporella inclusa* (see pl. XXVIII, figs. 8-11). The lunarium, however, is never prominent as in that species, nor is the posterior border of the aperture elevated as much as is usual among Lower Silurian ceramoporoids. Mesopores two or three to each zoœcium, placed indiscriminately among the larger apertures or one on each side and a third in front of the zoœcial orifice.

This species is closely related to both *D. vaupeli* and *communis* Ulrich, of the Cincinnati group of Ohio, but it is clearly not identical with either. In the first place the Trenton form is always smaller, so that they may be distinguished at once by the matter of size alone. Then the lunarial rim is not so high and the arrangement of the mesopores and other superficial parts generally a little different.

Formation and locality.—In the upper third of the Trenton shales, and in the Galena shales at St. Paul and Cannon Falls. Also in the Trenton limestone at Trenton Falls, New York, and Ottawa, Canada.

Genus CERAMOPHYLLA, *n. gen.*

Zoaria erect, bifoliate, the two layers grown together back to back; in other respects like *Ceramoporella* and *Diamesopora.*

Type: *C. frondosa,* n. sp.

The leaf-like zoarium of the only species of this genus known, is in many respects very much like that of *Rhinopora,* Hall. Still they are very different structurally, and I am satisfied that the relationship between them must be quite remote. On the other hand, *Ceramophylla* may be justly called a bifoliate *Ceramoporella*, just as *Diamesopora* would be a ramose one.

Ceramophylla frondosa, *n. sp.*

PLATE XXVIII, FIGS. 3-7.

Zoarium arising from a small basal expansion into erect, leaf-like, undulating fronds, celluliferous on both sides; thickness varying from 0.5 to 2.0 mm., but averaging less than 1 mm.; largest frond seen about 40 mm. high; margins rounded, exposing the mesial laminæ. At intervals of about 3 mm. the surface exhibits more or less conspicuous, substellate maculæ of mesopores. Zoœcial apertures ovate, oblique, the posterior margin well elevated, arranged more or less regularly in transverse and diagonally intersecting series, with about eight in 3 mm. Mesopores one, two, or three to each zoœcium, variously arranged, often irregularly distributed. In the most regular and normally developed examples the zoœcial apertures are ovate or pyriform and narrowest and highest behind, while in front of the depressed anterior side of each there is either one large triangular mesopore or three small ones, the whole in each case being contained in an obliquely concave rhomboidal space.

Of internal characters it is sufficient to say that diaphragms are wanting, the primitive or prostrate part of the tubes thin-walled and in most cases longer than the erect portion. In the latter the interspaces are very thick and, in vertical sections, crossed obliquely by dark lines.

Of associated bifoliate Bryozoa only *Eurydictya multipora* grows into broad fronds. But the merest tyro in the science must find the task of identifying the *Ceramophylla* an easy one.

Formation and locality.—Over one hundred examples were collected at St. Paul in the upper third (Phylloporina beds) of the Trenton shales. It is rarely met with in the same beds in Goodhue county.

Mus. Reg. No. 8381.

NOTE:—In the preceding report on the Bryozoa the author has adopted a merely provisional nomenclature of the divisons or beds into which the Trenton formation of Minnesota is divisible, partly upon lithological, but more especially upon paleontological grounds. This is in accordance with an agreement among the several authors at work on the paleontology of the Lower Silurian rocks of Minnesota. We believed, namely, that it was best to defer the adoption of permanent names for the faunal zones till the study of all the classes had been completed. The subject, therefore, will be found treated in a comprehensive manner in the introductory chapter to the volume. In that chapter a full list of the Trenton and Hudson River fossils found in the state is given, and each is referred to its proper horizon in the series.

<u>Errata.</u>

Page 107. Add *Eridotrypa* Ulrich, under Batostomellidae.
" – 11th line from bottom: for *Hedrella*, read *Hederella*.
145 – 3rd " " top – for some horizon " same horizon.
157 – Under *Pachydictya pumila*, add Pl. VIII, Figs. 4 & 5.
162 – 14th line from top: for *Ptaenopora* read *Phaenopora*.
171 – Under *E. confluens*, for Figs. 1–12 read 1–11.
172 – dele a at end of 24th line from top.
178 – 11th line from top, for *Anthropora* read *Arthropora*.
180 – After line 19, add, *S. exigua* Ulrich. Tr. limestone, Cannon.
220 – To *Formation and locality* add, Reappears in the upper part of the Galena shales.

281 – Under *Callopora ampla*, for Figs. 15, etc, read Figs. 13–15, etc.

107 – Add *Bythotrypa* Ulrich, under *Ceramoporidae*.

PLATE I.

		PAGE.

Fig. 1 to 5. VINELLA REPENS Ulrich.. 114

1. Two colonies attached to the inner side of a ventral valve of Strophomena septata W. and S.; natural size.
2. Portion of one of the colonies magnified ×18. The pores are absent, probably not having been preserved.
3. Another portion of same zoarium ×18, showing a nucleus with five divisions of the tubular stolon radiating from it. This portion of the specimen also preserves some of the pores marking the points where the zoœcia were attached.
4. Another specimen attached to a fragment of shell; natural size.
5. Small portion of same, ×18, with three tubes lying parallel with each other. The longitudinal lines are stronger than usual.

Upper third of the Trenton shales at St. Paul.*

Figs. 6 and 7. STOMATOPORA TENUISSIMA Ulrich.. 116

6. Portion of zoarium, ×9, showing its slender zoœcia and mode of growth, Utica horizon, Cincinnati group, Cincinnati, O.
7. Several zoœcia of same ×25, to show their apertures and form more clearly.

Figs. 8 to 12. STOMATOPORA PROUTANA S. A. Miller.. 117

8 and 9. Zoarium natural size and portion ×9.

10. Several zoœcia of same, ×25.
11. Several zoœcia of same colony, a little more slender than usual, ×25.
12. Several cells of a form of this species in which they are unusually large, ×25. (Survey Museum. Reg. No. 5926.)

Middle third of the Trenton shales at Minneapolis and St. Paul.

Figs. 13 to 21. STOMATOPORA INFLATA Hall.. 117

13 and 14. A colony attached to inner side of a fragment of shell, natural size, and a portion of same ×9.

15 and 16. Another colony, natural size and a portion ×9.

17. Three zoœcia of same, ×18, one of them preserving traces of the minute pores that pierce the wall.
18. Vertical section of one cell, ×18. Upper third of the Trenton shales at Cannon Falls, Minn.
19. Small portion of a large colony, ×9, growing upon the concave side of *Leptæna alternata;* Cincinnati hills.
20. Two zoœcia of same, ×18. In the Cincinnati form of this species the zoœcia are more inflated, and the whole zoarium more compact, and the growth more luxuriant than in the typical Trenton form.
21. Several zoœcia of another Cincinnati specimen, in outline, ×18, showing the unusual condition of three "gems" springing from one parent cell.

Figs. 22 and 23. STOMATOPORA TURGIDA Ulrich.. 118

An example of this species growing upon *Pachydictya splendens* Ulr., natural size and same ×9. Upper beds of the Hudson River gr., Wilmington, Ill. This species was recently discovered in the lower part of these beds in Fillmore county, Minn.

Fig. 24. PROBOSCINA TUMULOSA, n sp.. 119

An example of this species, natural size and portion ×9. Upper third of the Trenton shales, St. Paul, Minn.

Figs. 25 to 27. BERENICEA MINNESOTENSIS Ulrich.. 120

25 and 27. Two specimens of the natural size. Near Minneapolis, Minn. The original of fig. 27 belongs to the Survey Museum. Reg. No. 5925.

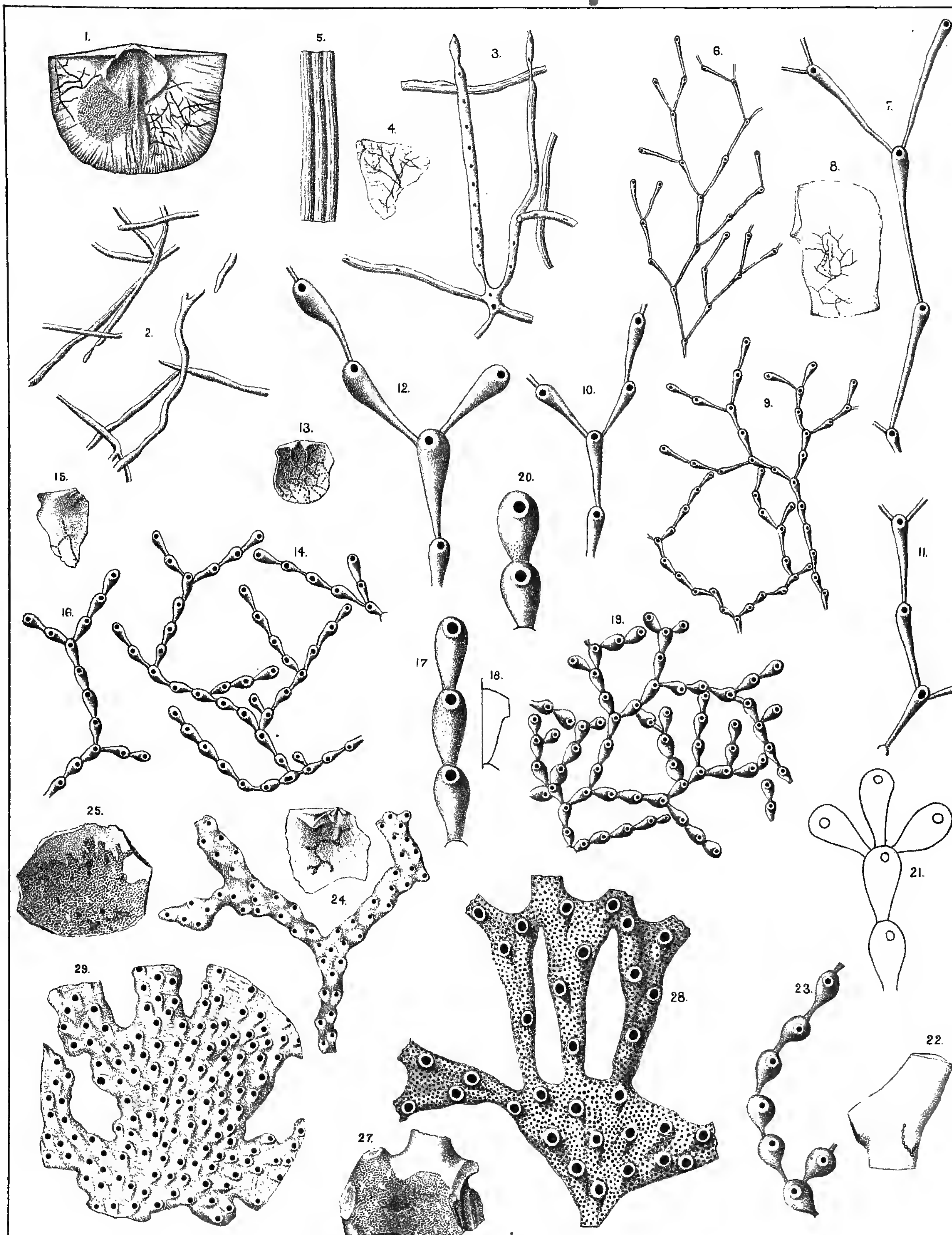
26. (29 on plate) Portion of original of fig. 25, ×9. (See also Plate II).

Fig. 28. PROBOSCINA FRONDOSA (Nicholson).. 119

Portion of specimen showing mural perforations very clearly, ×18. Cincinnati gr., Cincinnati, O.

---

*It is to be understood that when the collection containing the specimens illustrated on this and all of the following plates of Bryozoa is not mentioned, they belong to the author.



E O U & C S del et Lith
The Henderson Achert Lith. Co Cin. O

PLATE II.

PAGE

Fig. 1. BERENICEA MINNESOTENSIS Ulr. 12

Small portion of the original of plate I, fig. 27, ×18, showing zoœcial apertures less constricted than usual, and portions of two non-celluliferous spots.

Figs. 2 and 3. DIASTOPORINA FLABELLATA Ulr. 12

A complete zoarium of this species, of the natural size and ×7, showing arrangement of zoœcial apertures, fine interstitial striæ, and obscure concentric wrinkles. A small tubiculous annelid is attached to the frond. Upper part of the Galena shales at Cannon Falls, Minn.

3. Portion of same ×18, to show the characters of the species more clearly.

Figs. 4 to 6. MITOCLEMA (?) MUNDULUM Ulr. 12

4 and 5. Two fragments, nat. size and ×9.

6. Original of fig. 5, ×18.

Upper part of the Galena shales at Cannon Falls, Minn.

Fig. 7. ARTHROCLEMA BILLINGSI Ulr. 19

View of the type of this species, natural size. (Introduced to show mode of growth prevailing in this genus.)

Trenton limestone, Ottawa, Can.

Figs. 8 to 11, 25, and 28 to 33. ARTHROCLEMA ARMATUM Ulr. 20

8. Large segment of the primary series, showing a sharply defined articulating socket; natural size and ×18. This figure was inadvertently placed upside down.

9. Opposite side of another segment of the primary set, ×18. This and the preceding specimen is as thick as any noticed but not as long.

10. Complete segment of the secondary set, ×18.

11. Upper three fifths of another secondary segment, finely preserved, ×18. Upper part of the Galena shales near Cannon Falls, Minn.

25. Vertical section, ×25, of a primary segment somewhat doubtfully referred to this species. Upper third of the Trenton shales, St. Paul, Minn.

28. Transverse section of a small segment (?secondary) ×25. Cannon Falls, Minn.

29 and 30. Transverse and vertical sections of small segments found associated with the original of fig. 25.

31 and 32. A transverse, and the lower half of a vertical section, ×25, of full-grown primary segments. Cannon Falls, Minn.

33. Vertical section of a secondary segment, eqally enlarged and from the same horizon and locality as the preceding.

Figs. 12 to 15. ARTHROCLEMA PULCHELLUM Billings. 19

12. Vertical section of secondary segment, ×25.

13. Transverse section of primary segment, ×25.

14 and 15 Transverse sections, ×25, of two secondary segments, one with six, the other with seven rows of zoœcia. These sections were prepared from authentic examples collected at Ottawa, Can., from the Trenton limestone.

Figs. 16 to 21 and 23. ARTHROCLEMA CORNUTUM Ulr. 20

16. A continuous series of four primary segments, natural size, and three of them ×7, showing the articulating sockets near the base of each.

17. A similar series of segments, consisting of seven of the secondary order, natural size, with five of them ×7.

18 and 19. Two segments of the secondary order, ×18, one with three cycles of zoœcial apertures, the other with four. They differ also in the ornamentation.

20 and 21. Opposite sides of rather small but very perfect primary segment, natural size and ×18. (See also plate III.)

23. Transverse section of primary segment, ×18, showing five rows of zoœcia.

Middle third of the Trenton shales at Minneapolis, Minn.

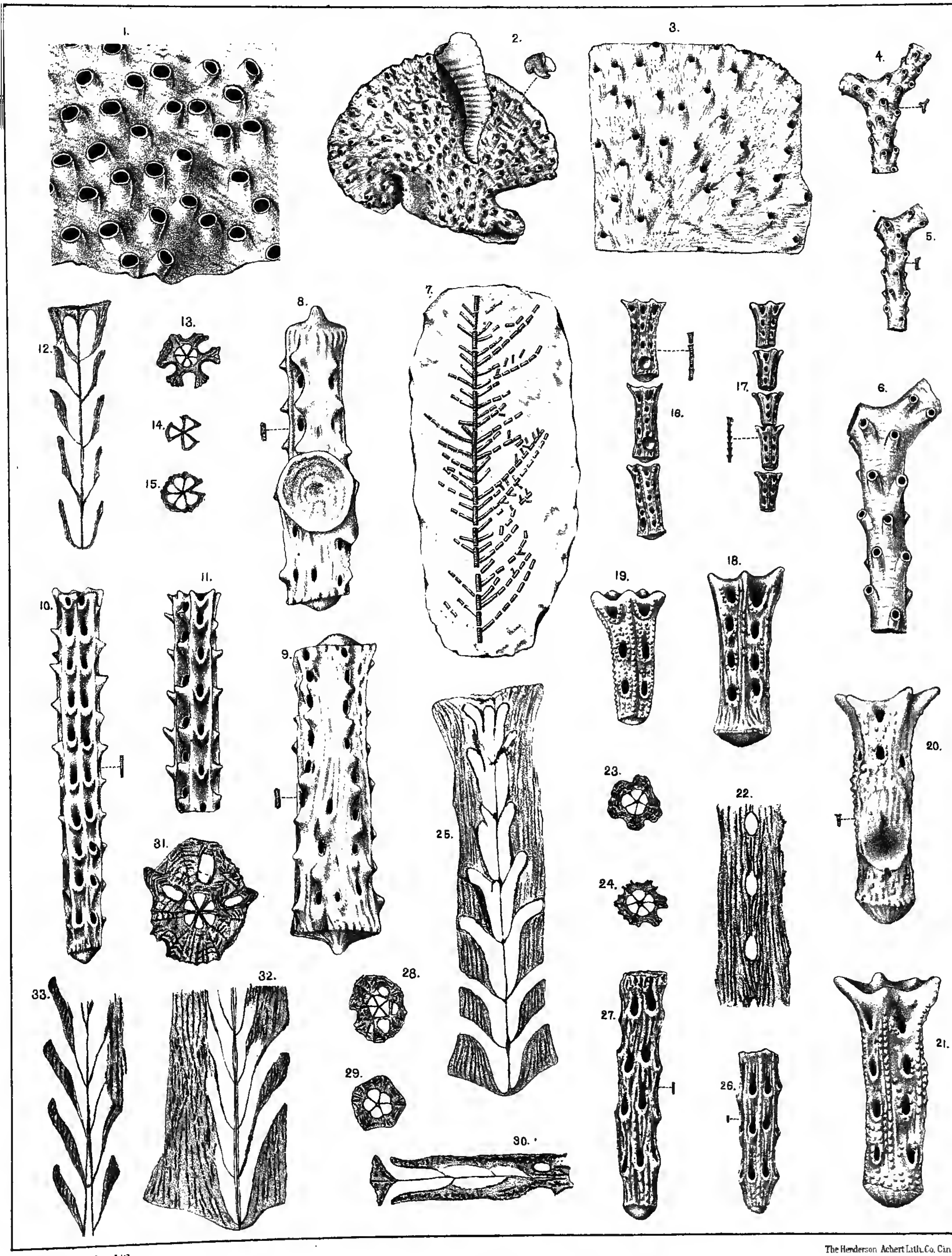
Figs. 22 and 24. ARTHROCLEMA STRIATUM, n. sp. 1

Tangential section, ×28, and tranverse section, ×18. (See also plate III.)

Figs. 26 and 27. ARTHROCLEMA sp. undet. 2

Two segments, the first incomplete, showing slight differences in ornamentation; ×18.

Trenton shales near Fountain, Minn.



E O U. & C.S. del et. Lith

The Henderson Achert Lith. Co. Cin. O.

PLATE III.

PAGE

Figs. 1 to 3. HELOPORA DIVARICATA Ulr. 19
1. A segment of the natural size and ×7, Minneapolis. Minn.
2. Portion of same, ×18. Only three of the four rows of zoœcia to be seen in this view have been drawn.
3. Transeverse section, ×18, showing a spiral development of the zoœcia.
Lower third of the Trenton shales at Minneapolis, Minn.

Figs. 4 to 6. HELOPORA SPINIFORMIS Ulr. 19
4. A segment natural size, and lower portion of same ×18.
5 and 6. Vertical and transverse sections, ×18.
"Glade" limestone at Lavergue, Tenn.

Fig. 7. ARTHROCLEMA ARMATUM Ulr. 20
A small segment supposed to belong to the tertiary set of this species, ×18. Cannon Falls, Minn. (See also plate II.)

Fig. 8. HELOPORA (?) sp. undet. 19
Nearly entire segment, ×18. Upper part of Galena shales, near Cannon Falls, Minn.

Fig. 9. HELOPORA ALTERNATA Ulr. 19
About three fourths of a segment of this species, ×18. Middle third of the Trenton shales, Minneapolis, Minn. It is within the possibilities that these segments may belong to the tertiary set of *Arthroclema striatum* Ulr.

Fig. 10. HELOPORA MUCRONATA Ulr. 19
A segment of this form natural size, and the greater part of it ×18. The specimens upon which this species is found may prove to belong to *Arthroclema armatum* Ulr. Upper part of Galena shales, near Cannon Falls, Minn.

Figs. 11 to 12. HELOPORA HARRISI James 19
11 and 12. Two segments, natural size and ×18.
11*a*. Portion of original of fig. 11, ×50.
11*b*. Transverse section of a segment, ×50.
Hudson River group, Waynesville, Ohio.

Figs. 13 and 14. ARTHROSYLUS CONJUNCTUS Ulr. 18
13. Lateral view of the central portion of a segment, ×18.
14. View of small portion of non-celluliferous side of same, ×18.
Trenton shales, near Fountain, Minn.

Figs. 15 and 16. ARTHROSTYLUS OBLIQUUS Ulr. 18
Two views of a segment of this species, ×18, in the first showing the non-celluliferous side with the upper extremity and about three-fourths of the length, in the second the central portion turned so as to show the lateral aspect.
Lower third of the Trenton shales at Minneapolis, Minn.
Beneath fig. 15 a small figure is erroneously marked with the number 16. This represents a transverse section of the type of the genus *A. tenuis* (James), from the lower part of the rocks at Cincinnati, Ohio.

Figs. 17 to 20. NEMATOPORA GRANOSA Ulr. 20
17. Portion of unbranched fragment, ×18, showing the granulose angles and interspaces, and narrow zoœcial apertures; the latter in five rows.
18. Bifurcating fragment, ×18, with the rows of granules slightly flexuous.
19 and 20. Portion of slightly worn fragment, and end view of same, ×18. This has only four rows of zoœcia.
Upper part of Galena shales, near Cannon Falls, Minn.

Figs. 21 to 23. NEMATOPORA CONFERTA Ulr. 20
Zoarium of this species, natural size, ×9, and portion of same ×18. Upper part of Galena shales, near Cannon Falls, Minn.

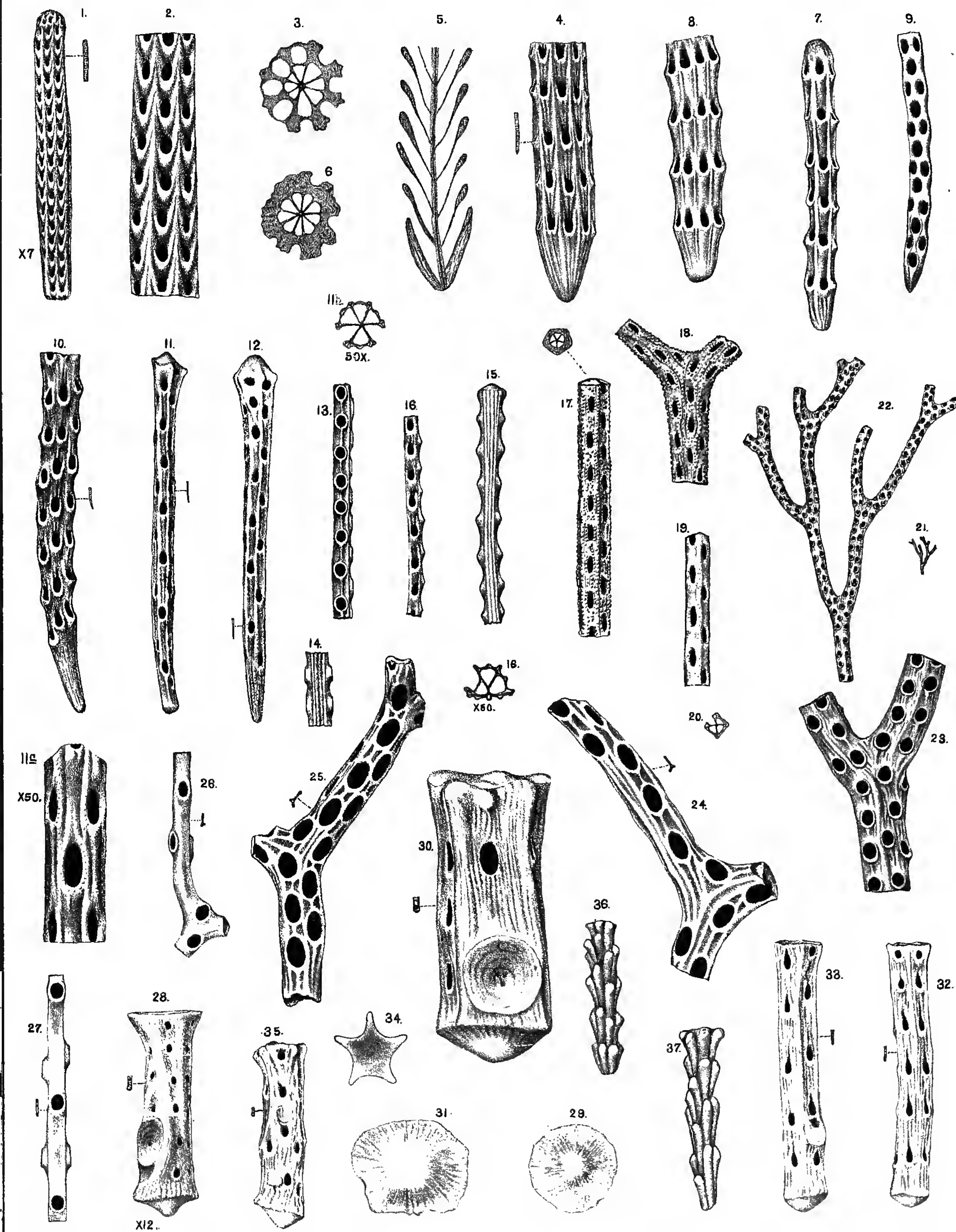
Figs. 24 and 25. NEMATOPORA OVALIS Ulr. 20
Two fragments of this opecies, natural size and ×18, the first with four rows of zoœcia, the other with five. Upper part of Galena shales, near Cannon Falls, Minn.

Figs. 26 and 27 NEMATOPORA DELICATULA Ulr. 20
Two fragments of the exceedingly delicate zoarium of this species, natural size and ×18. Upper part of Galena shales, near Cannon Falls, Minn.

Figs. 28 to 33. ARTHROCLEMA STRIATUM, n. sp. 19
28. Primary segment, natural size and ×12, with a large articulating socket and expanding ends.
29. Lower end of same, ×18.
30 and 31. Lateral and end views of a large and strongly striated primary segment, natural size and ×18. The zoœcial apertures are incorrectly represented in this figure. (See correction p. 199, sixth line from top.)
32 and 33. Two segments of the secondary set, natural size and ×18. One has five cycles of zoœcia and an articulating socket, the other six cycles and no distinguishable socket. (See also plate II.)
Middle third of the Trenton shales, Minneapolis, Minn.

Fig. 34. ARTHROCLEMA CORNUTUM Ulr. 20
View of upper end of the segment represented by fig. 18 on plate II; ×18.

Figs. 35 to 37. ARTHROCLEMA, sp. undet. 20
35. Slightly abraded segment, natural size and ×18. An obscure, subcentrally situated, articulating socket is distinguishable.
36 and 37. Two internal casts of the zoœcia, ×18, showing their spiral arrangement in the segments.
Upper third of the Trenton shales, St. Paul, Minn.



E. O. U. & C. S. del. et Lith

The Henderson Achert Lith. Co. Cin. O.

PLATE IV.

PAGE.

Figs. 1 to 7. PHYLLOPORINA SUBLAXA, Ulr. 20

1 and 2. Reverse side of small fragment, natural size and portion of same ×9, showing striated character of this side in young or exfoliated examples. Lower Trenton limestone, Minneapolis, Minn. Survey Museum. Reg. No. 5954.

3 and 4. Another fragment from the same locality, exposing the obverse side, natural size, and portion of same ×9.

5. Tangential section, ×18, showing appearance of zoœcia at varying depths.

6. Two transverse sections of branches, ×18.

7. A rather loosely woven frond from the "Glade" limestone at Lavergne, Tenn.; natural size.

Figs. 8 to 14. PHYLLOPORINA RETICULATA (Hall)... 21

8. A frond exposing the reverse side, natural size, Minneapolis, Minn.

9. Portion of same, ×9.

10 and 11. Another fragment from the same locality, natural size and ×9.

12. Small fragment, likewise from Minneapolis, exposing the obverse face, ×18.

13 and 14. Obverse and reverse sides of two fragments obtained from washings of Galena shale at Cannon Falls, Minn.; ×18.

15. Tangential section, ×18, of an example from Trenton Falls, N. Y.

Figs. 16 to 21. PHYLLOPORINA HALLI Ulr... 21

16. Reverse side of a specimen, natural size, showing irregular arrangement of fenestrules.

17. Celluliferous side of another fragment, natural size, showing the irregular solid swellings.

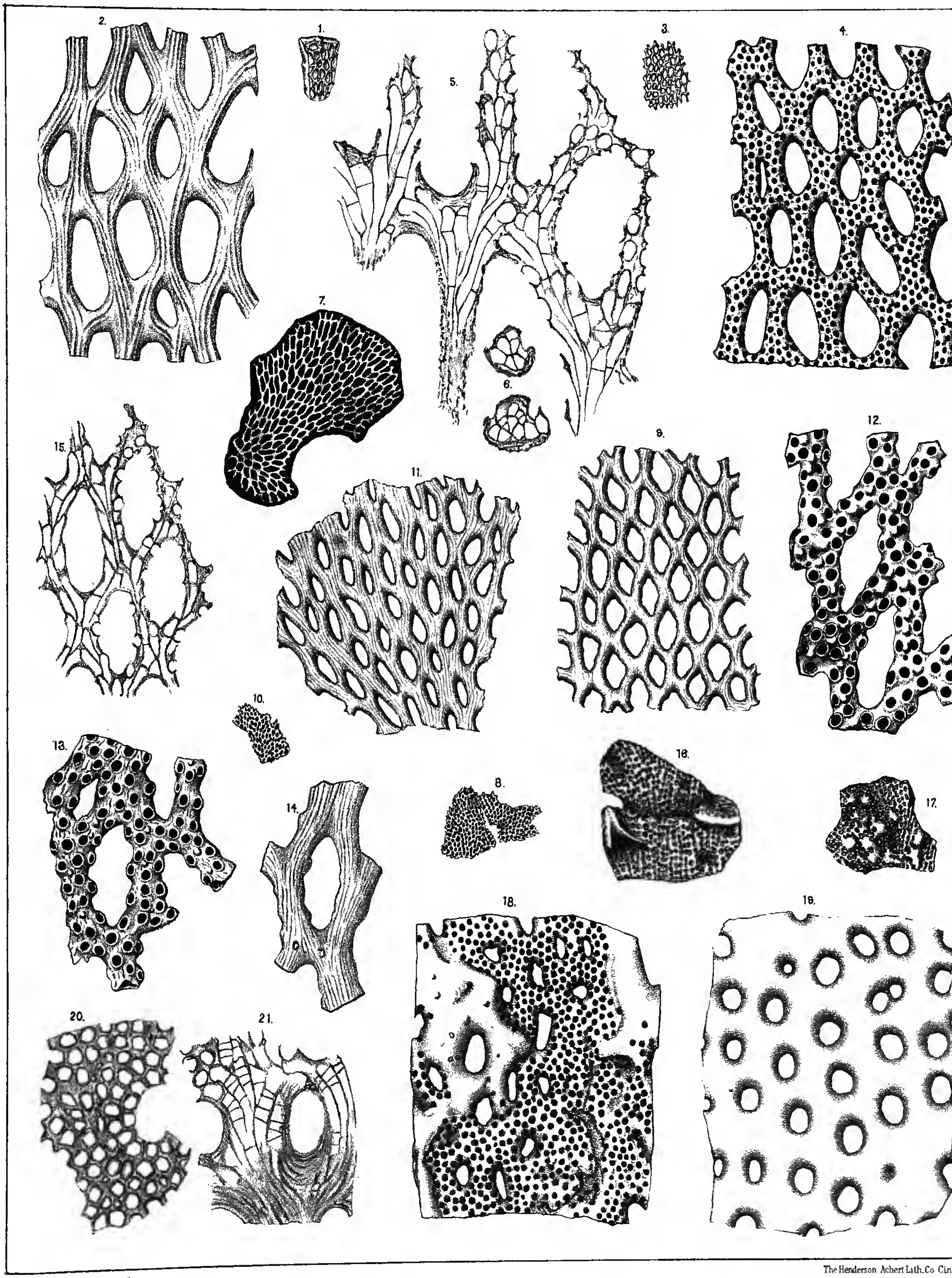
18. Surface of same, ×9.

19. Reverse side of same, ×9.

20. Tangential section, ×18, cutting the zoœcia just beneath their mouths.

21. Another portion of same section, ×18, where it divides the zoarium at a deeper level.

Upper third of the Trenton shales at St. Paul, Minn.



E.O.U & C.S. del et Lith

The Henderson Achert Lith. Co Cin. O

PLATE V.

PAGE

Figs. 1 to 10. PHYLLOPORINA CORTICOSA Ulr. 21:

1. A frond of this species exposing the poriferous or obverse side; natural size.

2 and 6. Reverse side of a fragment, natural size and a portion ×9.

3 and 7. Obverse side of another fragment, natural size and a portion ×9.

4 and 5. Two specimens of the basal portion of the zoarium, natural size.

8. Tangential section, ×18, cutting the zoœcial tubes at varying depths from the surface.

9. Transverse section of several branches, ×15.

10. Vertical section of a branch, ×18.

Upper third of the Trenton shales, near Cannon Falls, Minn.

Figs 11 and 12. RHINIDICTYA GRANDIS, n. sp. 13

A fine example from the "Lower Blue" limestone at Dixon Ill., natural size and a portion ×9. (See also Plate VI.)

Figs. 13 to 18. RHINIDICTYA MINIMA Ulr. 13

13. Three fragments of the natural size.

14 and 15. One of them ×9, and a portion of same ×18, showing the small zoœcial apertures and grano-striate character of the interspaces.

17. Tangential section of the variety MODESTA, ×18, showing the appearences of the zoœcia at various depths beneath the surface.

18. Tangential section of the typical form of the species, ×18.

Upper part of the Galena shales, near Cannon Falls, Minn.

Figs. 19 to 21. RHINIDICTYA PAUPERA Ulr. 12

19. A nearly complete specimen, natural size.

20 and 21. A fragment, natural size ×9 and ×18.

Upper third of the Trenton shales, St. Paul, Minn.

Figs. 22 to 25. RHINIDICTYA NEGLECTA n. sp. 13

22. A fragment of the natural size and a portion ×18, showing the usual characters of the species.

23, 24 and 25. Respectively, trarsverse, vertical, and tangential sections of a specimen wider than the original of fig. 22, but agreeing in all other respects with it.

Trenton limestone near Danville, Ky.

E. O. U. & C. S. del. et Lith.

The Henderson-Achert Lith. Co. Cin. O.

PLATE VI.

PAGE.

All the figurers on this plate except No. 18 are ×18.

Figs. 1 to 6, 12 and 13. RHINIDICTYA MUTABILIS Ulr. 125

1. Tangential section of an old and thick example of the usual form of this species. Figs. 6 and 12 represent transverse and vertical sections of same.

2 and 3. Tangential and vertical sections of a fragment of the var. SENILIS (see p. 127), showing the great abundance of the median tubuli and the structure of one of the solid spots.

4 and 5. Tangential and vertical sections of a well preserved and typical example.

6. Small portion of a transverse section prepared from the same specimen that furnished the originals of figs. 1 and 12.

12. Vertical section of a thick specimen. (See figs. 1 and 6). Only one side of the zoarium is entirely represented.

13. Tangential section of a young example.

For the external characters of this species see plate VII.

Middle third of the Trenton shales at Minneapolis and St. Paul.

Figs. 7 and 8. RHINIDICTYA FIDELIS Ulr. 134

7. Tangential section, showing structure immediately beneath the surface; 7*a*, small portion of same section showing appearances at the bottom of the vestibular region; 7*b*, another portion of same, showing the form of the primitive portion of the zoœcia and the minutely tubular character of the walls and mesial laminæ.

8. Vertical section of same specimen, showing well developed superior hemisepta.

Middle third of the Trenton shales at Minneapolis.

Figs. 9 to 11. EURYDICTYA MULTIPORA Hall (?) 139

Tangential, transverse, and vertical sections of a narrow frond from the upper third of the Trenton shales at St. Paul. (See also plates VII and XIV.)

Figs. 14 to 18. RHINIDICTYA TRENTONENSIS Ulr. 135

14 and 15. Transverse and vertical sections of a young example.

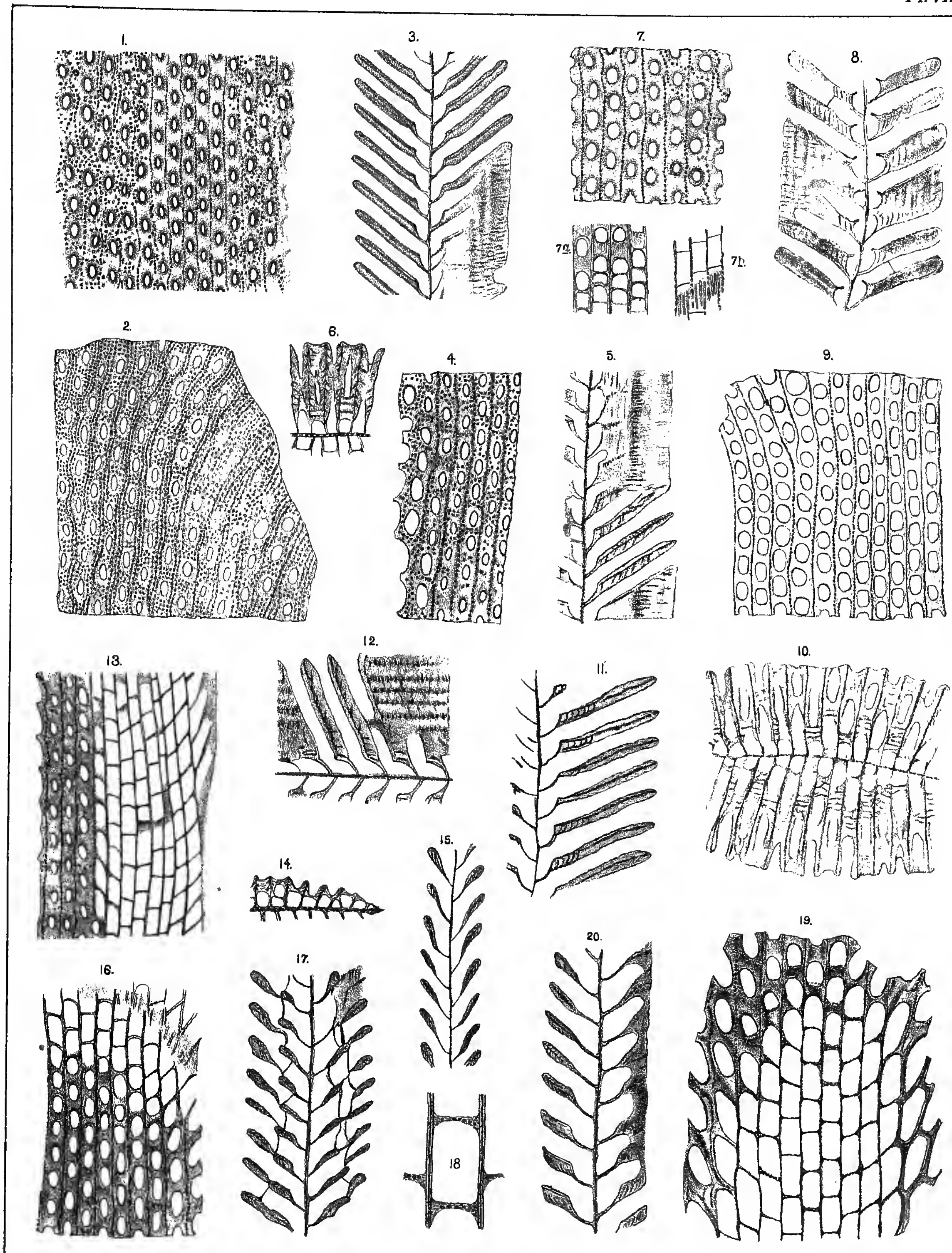
16 and 17. Vertical and tangential sections of a thicker specimen. In this each side is in part composed of two distinct layers of zoœcia.

18. Primitive or prostrate portion of one zoœcium of fig. 16, more highly magnified (×50). See also plate VII.

Lower third of the Trenton shales, Minneapolis, Minn.

Figs. 19 and 20. RHINIDICTYA GRANDIS, n. sp. 136

Vertical and tangential sections of a specimen from the "Lower Blue" limestone at Dixon, Ill.



E O U. & C.S. del et Lith.

The Henderson-Achert Lith. Co. Cin. O.

PLATE VII.

PAGE.

Figs. 1 to 5. RHINIDICTYA PEDICULATA, n. sp. 13

1 to 4. Four specimens of the natural size, showing the mode of growth prevailing in this species. Three of the specimens preserve the footstalk.

5. Surface of a slightly weathered example ×9. In better preserved examples the nonporiferous margins are much wider. (See description.)

Lower limestone of the Trenton formation, Minneapolis, Minn.

Figs. 6 to 9. RHINIDICTYA TRENTONENSIS Ulr. 13

6 to 8. Three fragments of the natural size.

9. A well preserved fragment of the natural size and ×9. (See also plate VI.)

Lower third of the Trenton shales, Minneapolis, Minn.

Figs. 10 to 15 and 18 to 21. RHINIDICTYA MUTABILIS Ulr. 12

10. Surface of an old and excellently preserved fragment, ×9.

11 to 14. Four representative specimens of the natural size. The original of fig. 11 belongs to the Survey Museum; Reg. No. 5939. It is from the upper third of the Trenton shales at St. Paul.

15. Portion of original of fig. 13, ×9, illustrating the appearance of a large number of specimens.

18. A finely preserved fragment, natural size and a portion ×9. In this specimen the zoœcia are unusually small.

19 to 21. A very young specimen (var. *minor* of my preliminary report,) natural size, a portion ×9, and several zoœcial apertures ×35. The margins are wide and sharp, the outer zoœcial apertures large and oblique, and the walls in the central part very delicately granulose. (See also plates VI and VIII.)

Middle third of the Trenton shales, Minneapolis and St. Paul, Minn.

Figs. 16 and 17. RHINIDICTYA MUTABILIS, var. SENILIS, n. var. 12

A specimen of the natural size and a portion ×9.

Middle third of the Trenton shales, St. Paul, Minn.

Figs. 22, 23, 25 to 28, and 32. RHINIDICTYA MALTABILIS, var. MAJOR Ulr. 12

22 and 23. A well preserved but narrow stipe of this variety of the natural size, and a few zoœcial apertures, with a portion of one of the solid spots or maculæ, ×18.

25 to 28. Four specimens of the natural size.

32. Small portion of the surface of the original of fig. 28, ×9. (See also plate VI.)

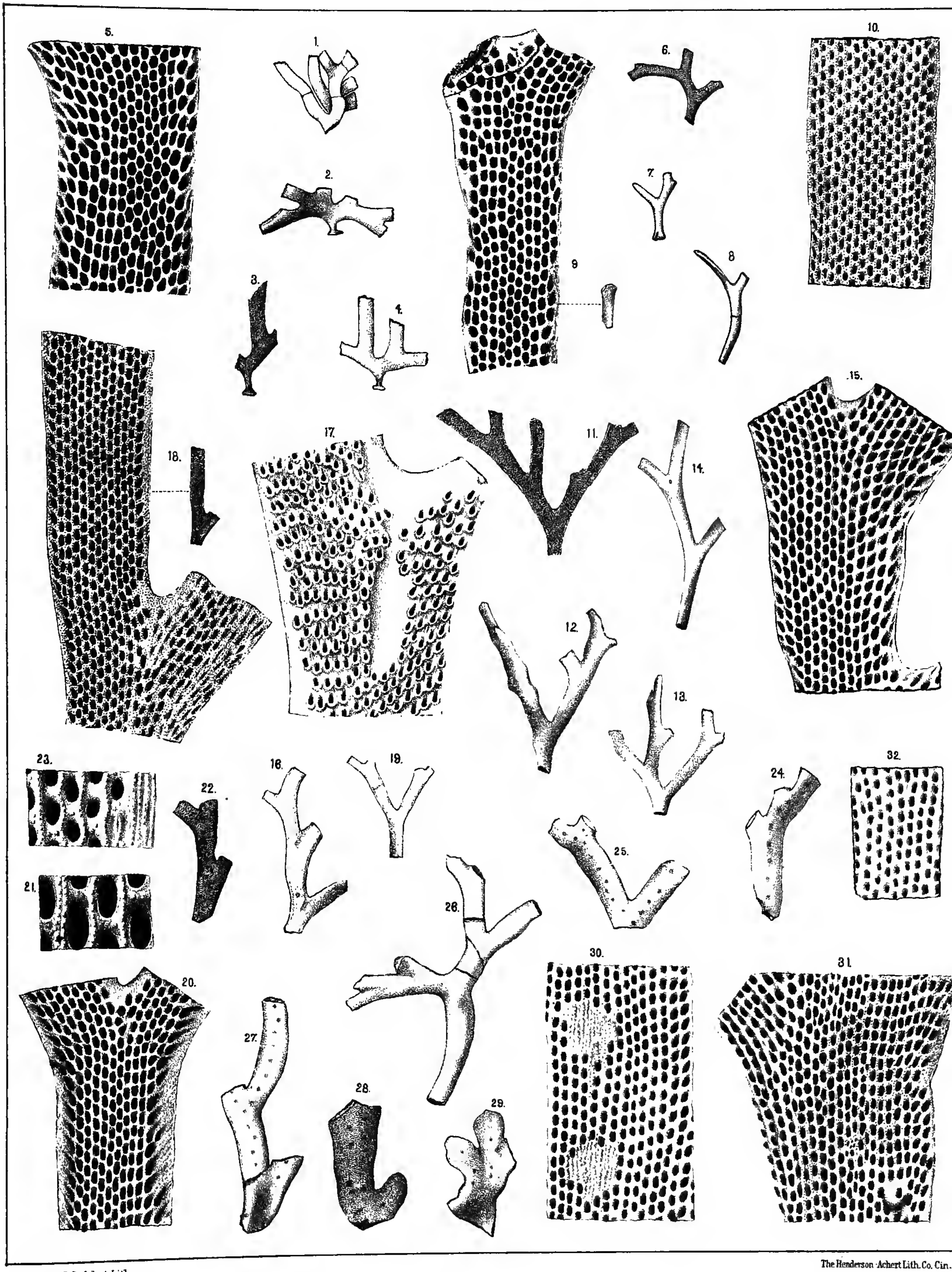
Middle third of the Trenton shales, St. Paul and Minneapolis.

Figs. 24 and 29 to 31. EURYDICTYA MULTIPORA (?Hall) 13

24 and 30. A narrow, parallel-margined example of the natural size and a portion ×9. This resembles *Rhinidictya mutabilis*, var. *major* to such a degree that it was at first regarded as belonging to that variety.

29 and 31. A small, irregularly divided frond, natural size and a portion ×9. This specimen is evidently young, being thin and but inconspicuously maculose. (See also plates VI. and XIV.)

Upper third of the Trenton shales at St. Paul, Minn.



E.O.U. & C.S. del et Lith

The Henderson-Achert Lith. Co. Cin. O.

PLATE VIII.

PAGE.

Figs. 1 to 3. RHINIDICTYA MUTABILIS Ulr.. 125

Three portions of an old example of this species ×9, showing, in 1, the thick, rounded and granulose margin, in 2, the shape of the zoœcial apertures at the upper extremity of the specimen, and in 3, their form near the lower end of same. (See also plates VI and VII.)

Figs. 4 and 5. PACHYDICTYA PUMILA Ulr.. 157

Two fragments of the natural size, and one of them representing the basal part of the zoarium, ×9. (See also plate X, and remarks on p. 158.)

Figs. 6 to 10. RHINIDICTYA EXIGUA Ulr.. 131

6 and 7. The basal part of a specimen of the natural size and ×9. One of the branches has three, the rest of the zoarium four rows of zoœcia.

8. A delicate fragment with only three rows of zoœcia.

9 and 10. A branching fragment of the natural size and the lower half ×9. This has from five to seven rows of apertures.

Lower third of the Trenton shales at Minneapolis.

Figs. 11 to 17. PACHYDICTYA ACUTA (Hall) and varieties.. 155

Figs. 11 and 12. A specimen of the natural size and a portion ×9. Trenton limestone, Trenton Falls, N. Y.

13. A very small specimen, with only six and seven rows of zoœcia, from the Galena limestone near Fountain, Minn.

14 to 16. Three specimens from the Galena shales near Cannon Falls, Minn.

17. Surface, ×9, of a well preserved fragment from the same horizon and locality as the preceding. (See also plate IX.)

Figs. 18 and 19. PACHYDICTYA ELEGANS, n. sp.. 154

18. A very nearly perfect zoarium of this species, natural size, from the lower part of the Galena shales at St. Paul. Later collections show that this species is exceedingly abundant at that locality and that the specimen here figured divides with greater frequency than usual.

19. Enlargement of the beautifully ornamented surface of same, ×18. (See also plate IX.)

Figs. 20 to 27. PACHYDICTYA OCCIDENTALIS Ulr.. 151

20 to 24. Five specimens of the natural size, illustrating the variable character of the zoaria.

25. Surface of fig. 24, ×9.

26 and 27. A frond of the natural size and a portion of its surface ×9, traversed by irregular grooves caused by interruptions in the development of the zoœcia. (See also plate IX.)

Upper third of the Trenton shales at St. Paul.

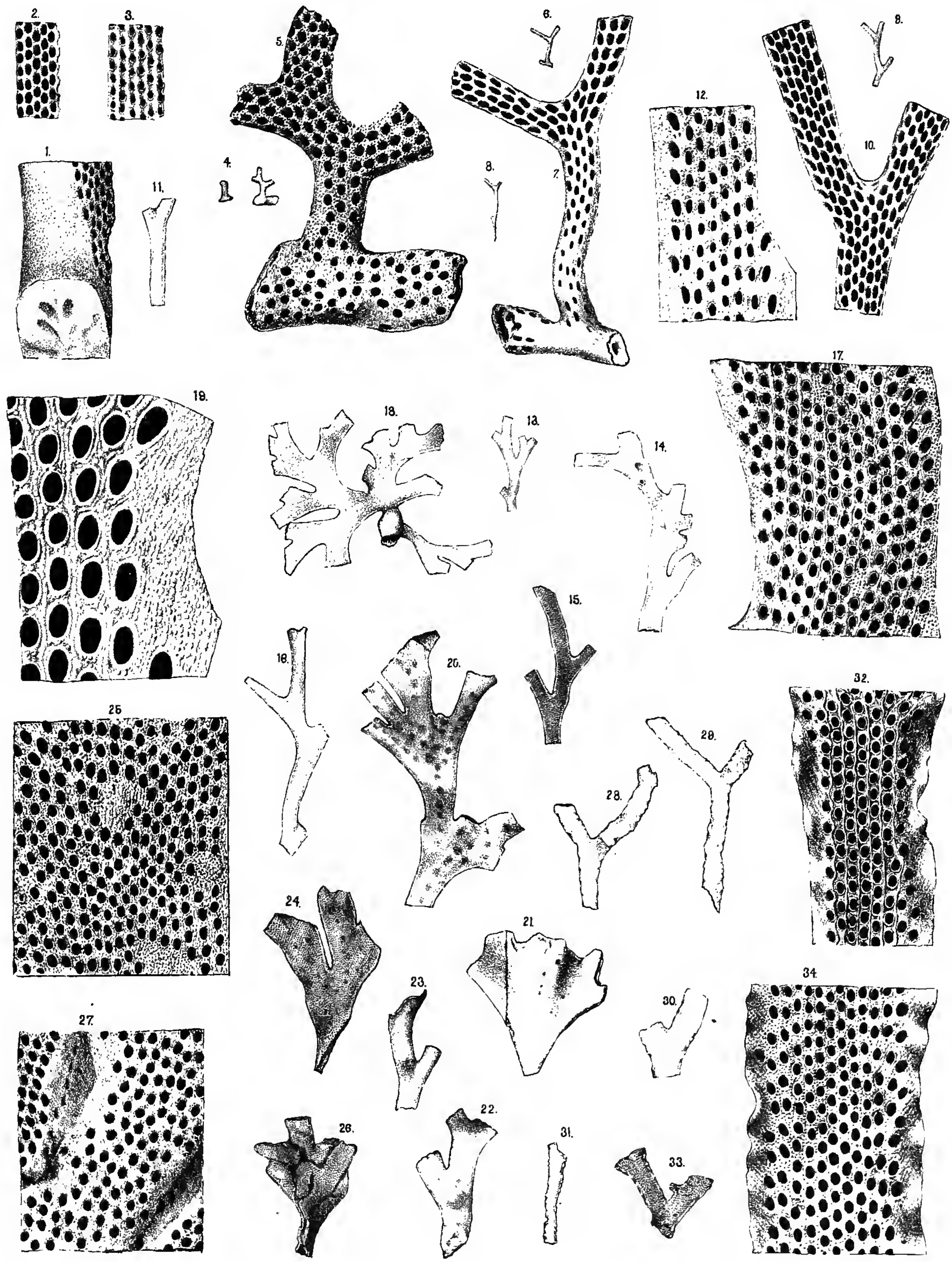
Figs. 28 to 34. PACHYDICTYA FIMBRIATA Ulr.. 152

28 to 30. Three specimens of the natural size, the last one the widest seen.

31 and 32. A very narrow and seemingly young example, natural size and the upper part ×9.

33 and 34. An excellently preserved fragment of the natural size and a portion ×9. This presents the fully matured condition of the species. (See also plate IX.)

Middle third of the Trenton shales at Minneapolis and St. Paul.



E O U & C.S. del et Lith

The Henderson Achert Lith. Co. Cin. O

PLATE IX.

PAGE

Figs. 1 to 5. PACHYDICTYA FOLIATA Ulr. 149

1. Tangential section, ×18, cutting the zoarium a little obliquely. The figure which was inadvertently placed upside down on the stone represents a spot of the section where inequality of level caused the zoarium to be divided in such a manner that it brings into rapid review the various changes from the base of the zoœcial tubes to the surface. The shaded and vertically lineate zone in the lower part of the figure represents the median tubuli and laminæ.
2. Tangential section ×18, showing structure in the outer half of one of the layers of zoœcial tubes in a well preserved specimen.
3. Small portion of same ×35, to show the minutely tubular character of the zoœcial walls.
4. Vertical section, ×18.
5. About two thirds of the width of a transverse section, ×18, showing median tubuli very distinctly. (See also plate X.)

Lower third of the Trenton shales, St. Paul and Minneapolis.

Figs. 6 and 10. PACHYDICTYA OCCIDENTALIS Ulr. 151

6. Represents a small portion of a tangential section just beneath a bifurcation of the zoarium, ×18. At this point it is common to find, as in the present case, that the longitudinal interspaces are wider and with more lines of median tubuli than usual.
10. Vertical section ×18. (See also plate VIII).

Upper third of the Trenton shales at St. Paul.

Fig. 7. PACHYDICTYA ACUTA (Hall) 155

Tangential section of a specimen from Cannon Falls, Minn. (See also plate VIII).

Figs. 8 and 9. PACHYDICTYA ELEGANS, n. sp. 154

8. Tangential section. ×18, cut obliquely so as to show parts of both sides of the zoarium. This specimen was very old and thick and in the outer part (upper third of figure) developed two extra lines of median tubuli in each longitudinal interspace. The end spaces are also unusually long.
9. Small portion of same section, ×35. (See also plate VIII).

Base of Galena shales, St. Paul, Minn.

Figs. 11 and 12. TRIGONODICTYA CONCILIATRIX Ulr. 16

11. Transverse section, ×18.
12. Tangential section, ×18, from a specimen in an unusually good state of preservation. (See also plate X).

Upper third of the Trenton shales near Cannon Falls, Minn.

Figs. 13 and 14. PACHYDICTYA FIMBRIATA Ulr. 15

13. Tangential section, ×18. At the upper end of the figure the section sinks to the level of the median laminæ.
14. Small portion of one of the longitudinal interspaces and adjoining walls of several zoœcia, ×35. (See also plate VIII).

Middle third of the Trenton shales, St. Paul and Minneapolis.

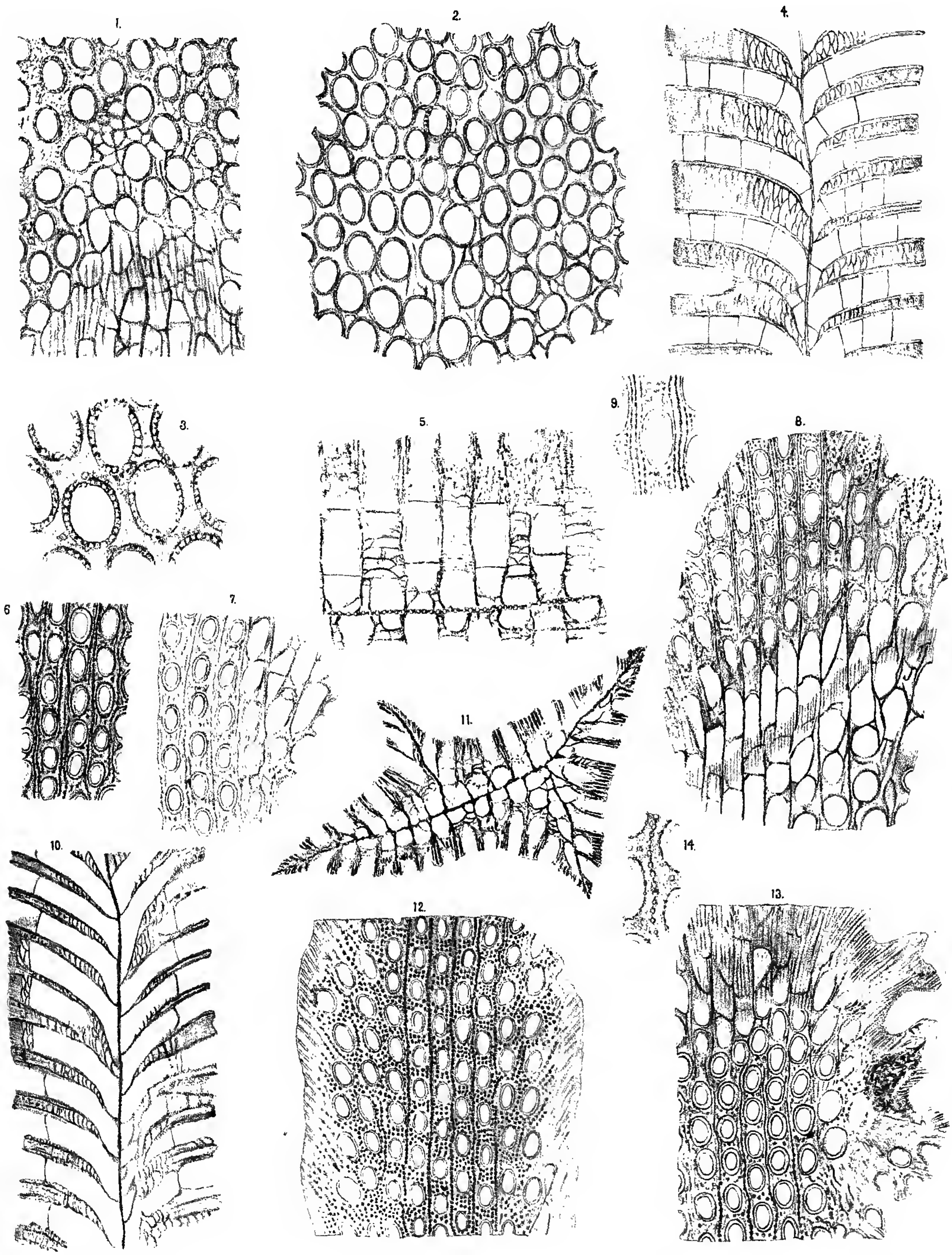

1.
2.
4.
3.
5.
9.
8.
6
7.
11.
10.
14.
12.
13.

PLATE X

PAGE

Figs 1 to 4. PACHYDICTYA PUMILA Ulr.. 15

1. A group of specimens of the natural size.

2 and 3. Two fragments, natural size and ×9, with some of the zoœcial apertures closed.

4. The basal part of a rather young example, natural size and ×9. (See also plate VIII).

Upper part of the Galena shales, near Cannon Falls, Minn.

Figs. 5 to 10. PACHYDICTYA FOLIATA Ulr.. 14

5 to 8. Four specimens of the natural size. Fig. 6 presents the unusual condition of raised maculæ.

9. Surface of fully matured example, ×9.

10. Surface of a young zoarium, ×18. (See also plate IX).

Figs. 11 to 14. PACHYDICTYA TRISERIALIS Ulr.. 15

11. Portion of a block of limestone with a group of the slender ramulets of this species, natural size.

12. Surface of an old example, ×18, on which many of the zoœcial apertures preserve the closures.

13 and 14. Two transverse sections, ×25, the first prepared from a young example, the second from one like the original of fig. 12.

Trenton limestone, Montreal, Can.

Figs. 15 to 20. TRIGONODICTYA CONCILIATRIX Ulr.. 16

15 to 19. Five specimens of the natural size, illustrating the zoarial variability of the species.

20. Surface of well preserved example ×9. (See also plate IX.)

Upper third of the Trenton shales near Cannon Falls, Minn.

Figs. 21 to 25. STICTOPORELLA CRIBROSA Ulr.. 18

21. Nearly complete zoarium of the prevailing type of this species, natural size.

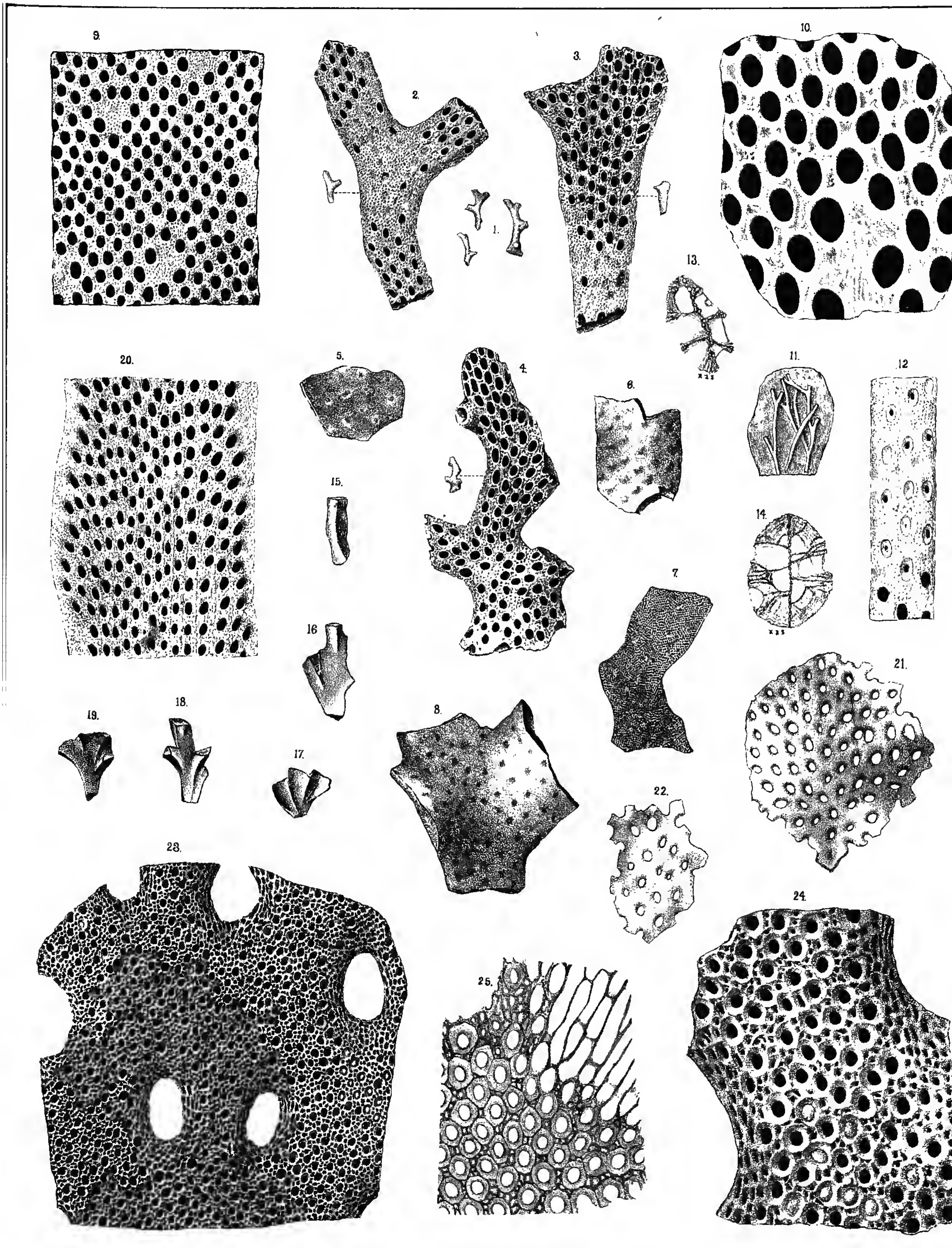
22. A thin fragment less regularly developed than usual.

23. Surface of an excellently preserved example, ×9.

24. Another portion of same ×18. In this specimen the mesopores are very numerous.

25. Tangential section of an average specimen, ×18. In the upper part of the figure the section descends to the level of the prostrate portion of the zoœcial tubes. (See also plate XI.)

Middle third of the Trenton shales at Minneapolis.



E. O. U. & C. S. del. et. Lith.

The Henderson-Achert Lith. Co. Cin. O.

PLATE XI.

PAGE.

Figs 1 to 3, 6, and 8 to 11. STICTOPORELLA ANGULARIS Ulr.. 18

1 to 3. Three specimens of the usual form of this species, natural size.

6. Surface of an average example, ×9.

8, 10 and 11. Tangential, transverse, and vertical sections, ×18, prepared from the oldest example at hand.

9. Small portion of a tangential section ×50, showing the minutely tubular character of the divisional line between adjoining zoœcial walls.

Lower third of the Trenton shales at St. Paul and Minneapolis.

Figs. 4, 5 and 7. STICTOPORELLA ANGULARIS, var. INTERMEDIA, n. var............................ 18

4. A small subfrondescent example from the base of the shales at Minneapolis.

5. A fragment of the usual form of the variety from the same horizon in Fillmore county.

7. Surface of same ×18, showing the extreme paucity of mesopores and in the upper left corner a portion of one of the clusters of thin-walled zoœcia.

Figs 12 to 19. STICTOPORELLA FRONDIFERA Ulr.. 18

12 to 14. Three specimens of this species, natural size. The original of fig. 14 belongs to the Survey Museum. It is one of a number bearing the register number 5946.

15. Surface of original of fig. 12 ×9.

16. Tangential section of an average specimen, ×18.

17. Small portion of same section ×50, to show the structure of the inter-zoœcial lines.

18. The basal or prostrate portion of several zoœcial tubes as shown in another tangential section, ×18.

19. Vertical section, ×18.

Lower third of the Trenton shales at Minneapolis.

Figs. 20 and 21. STICTOPORELLA RIGIDA Ulr................ 18

20. A fragment of the natural size and the greater part of it ×9.

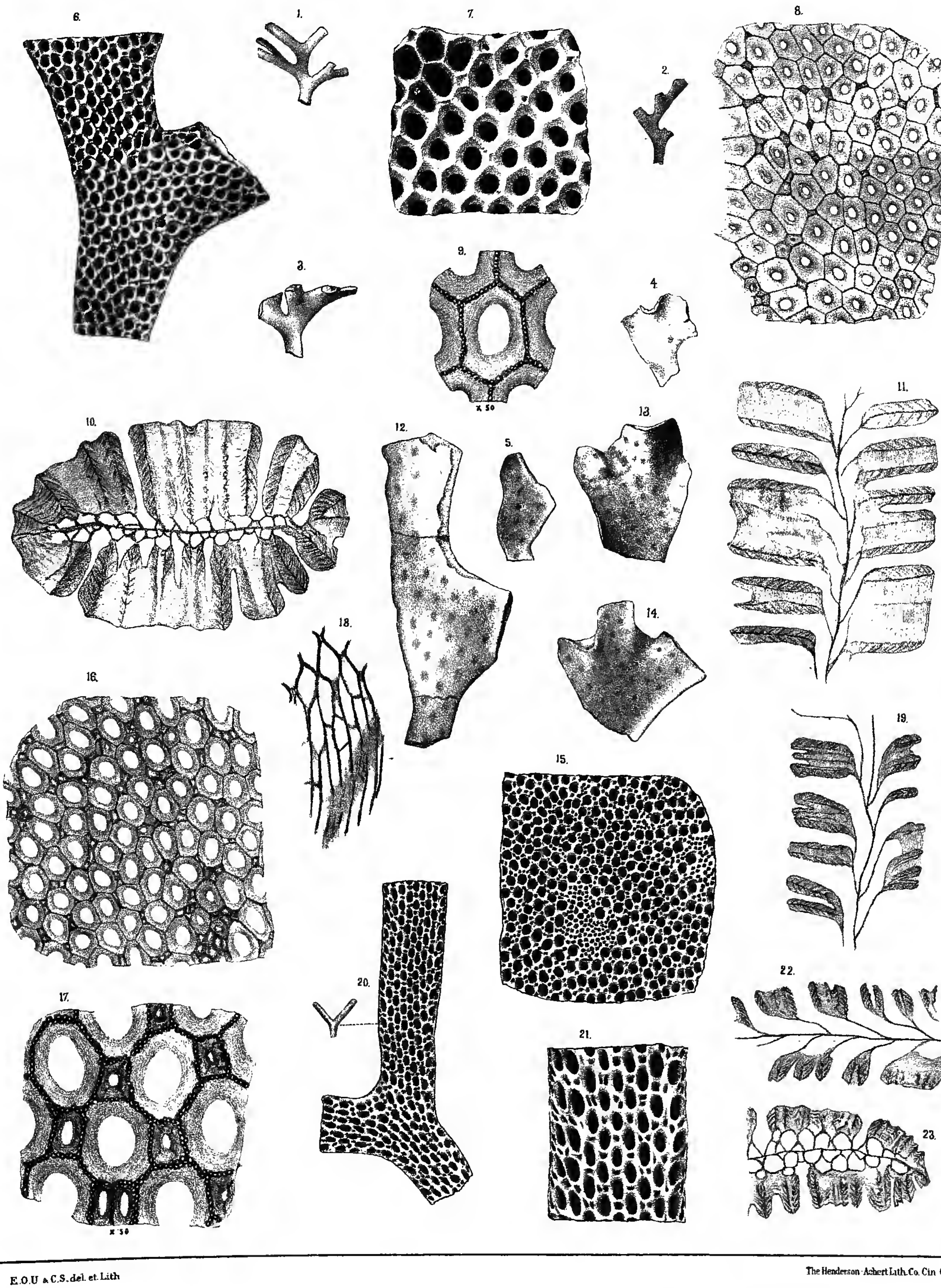
21. Portion of same, ×18.

Lower part of the upper third of the Trenton shales at Fountain, Minn.

Figs. 22 and 23. STICTOPORELLA CRIBROSA Ulr.. 184

22. Vertical section, ×18.

23. Transverse section, ×18. (See also plate X).



E.O.U & C.S. del. et. Lith. The Henderson-Achert Lith. Co. Cin. O.

PLATE XII.

PAGE

Figs. 1 to 4, 30 and 31. □ ESCHAROPORA ANGULARIS, n. sp. 168

1 and 2. A small specimen of natural size and the greater portion of it ×9.

3 and 4. A large specimen of the natural size and a portion of the upper half of its surface ×18.

30 and 31. Vertical and tangential sections, ×18.

Trenton limestone, Minneapolis.

Figs. 5 to 29. ESCHAROPORA SUBERECTA Ulr. 168

5 to 17. A series of specimens, most of them above the average in size and the four last with from one to three rows of monticules.

18 and 19. The central and basal portions of the original of fig. 9, ×9.

20. Part of same, ×18. The characters as shown in this specimen are to be regarded as typical for the species in its younger stages.

21. Surface of another small example, ×18, with the marginal rows of zoœcia unusually conspicuous.

22. Surface of the basal third of the original of fig. 15, ×18. The features here presented are unusual.

23. Surface of the upper part of the original of fig. 16, ×18.

24. Surface of the original of fig. 17, ×18. In the specimen the zoœcial apertures manifest a tendency to arrange themselves in an obscurely pinnate manner.

25. Tangential section of an example corresponding to fig. 9; ×18.

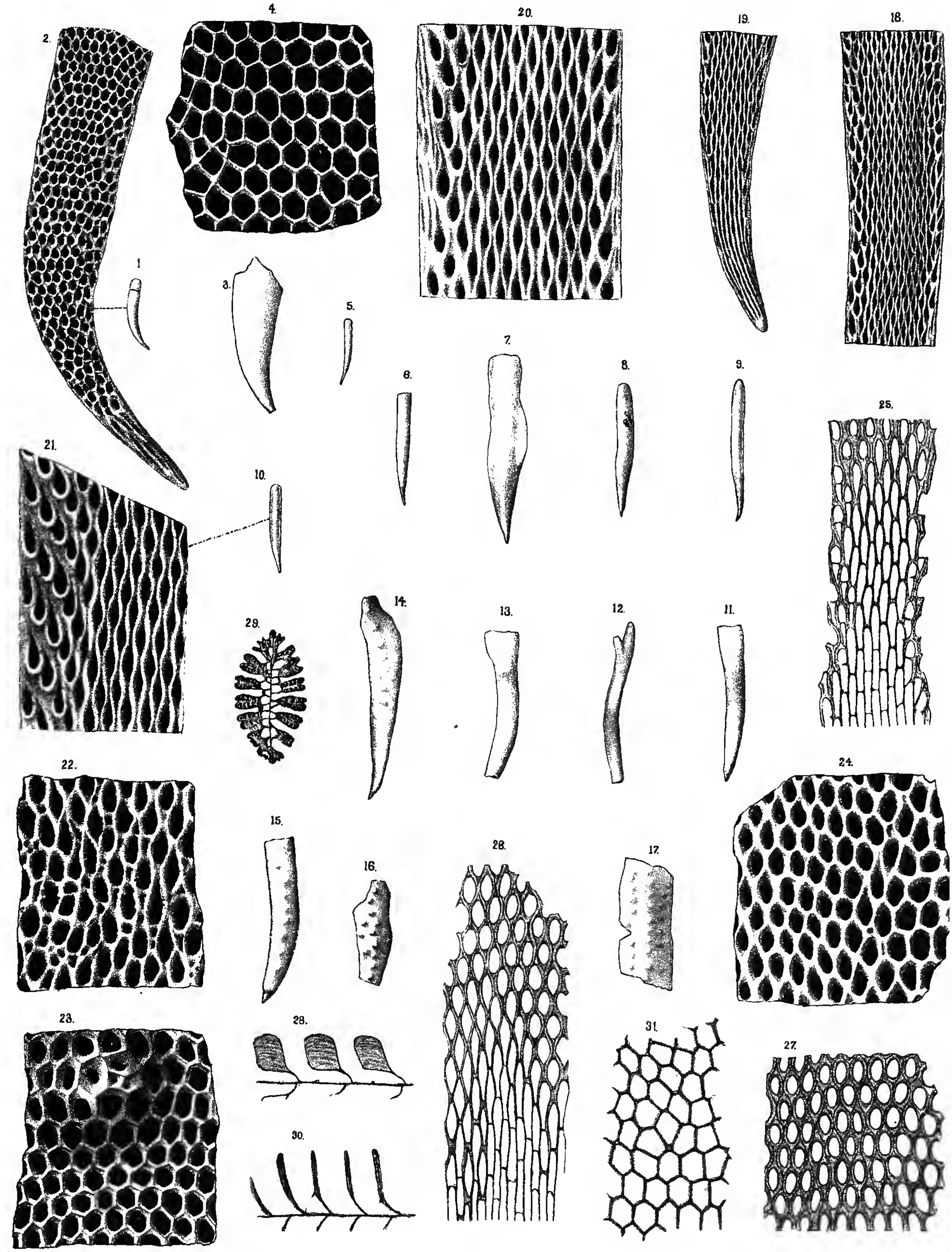
26. Tangential section of a specimen of the size of fig. 8, or a trifle larger; ×18.

27. Tangential section, ×18, showing the appearance just beneath the surface of an old example.

28. Vertical section of several zoœcia prepared from an average specimen, ×18.

29. Transverse section of same ×12.

Middle third of the Trenton shales at St. Paul and Minneapolis.



E.O.U. & C.S. del et Lith

The Henderson Achert Lith. Co. Cin. O.

PLATE XIII.

PAGE.

Figs. 1 to 11. ESCHAROPORA CONFLUENS, n sp. 171

1. A specimen that preserves the pointed articulating base; natural size.
2. Well preserved fragment, the surface of which is enlarged in fig. 5.
3. Portion of a large specimen with comparatively remote bifurcations and obscure monticules; natural size.
4. Incomplete basal part of another large zoarium; natural size.
5. Surface of the original of fig. 2, ×9. The line above indicates the contour of the surface in a transverse section.
6. Tangential section, ×18, of a well preserved example. The figure embraces about two-thirds of the width of the branch, the right side being marginal.
7. Several zoœcia of the same section, ×35, showing the mural lineation.
8. Another portion of the same section, ×18, showing the prostrate part of the zoœcia.
9. Left half of another section, ×18, prepared from a specimen in a less favorable (the usual) state of preservation. In this example the marginal zoœcia were uncommonly large

10 and 11. Transverse and vertical sections ×18.

Middle third of the Trenton shales at Minneapolis.

Figs. 12 and 13. ESCHAROPORA (?) LIMITARIS, n sp. or var 172

12. A very large specimen, provisionally referred to this species; natural size. Middle third of the Trenton shales at Minneapolis. Survey Museum. Reg. No. 5930.
13. A specimen of the average size of the species as it occurs in the lower third of the shales at Minneapolis. (For internal structure see figure 9 on page 172.)

Figs. 14 to 17. PHÆNOPORA INCIPIENS, n. sp. 174

14. A fragment of the natural size and a part of it ×18. Trenton limestone, Montreal, Can.
15. The basal part of a zoarium from the Trenton limestone at Chimney Point, Vermont.
16. Tangential section, ×18, of a specimen from Montreal.
17. Tangential section of another specimen from Montreal, ×28, showing structure immediately beneath the surface.

Figs. 18 to 21. STICTOPORELLA EXIGUA, n. sp.*

18. Portion of the delicale zoarium of this species, natural size.
19. Surface of one of the branches ×18.
20. Tangential section ×28.
21. Transverse section ×18.

Trenton limestone, Montreal, Can.

Figs. 22 to 26. PHÆNOPORA WILMINGTONENSIS, n sp 175

22. Fragmentary example of the natural size.
23. Surface of same ×9.
24. Two portions of a tangential section, ×18, the upper showing the appearance just beneath the surface, the lower just over the prostrate part of the zoœcial tubes.
25. One of the zoœcia and portions of the adjoining ones ×35 to show the minute structure of the walls.
26. Vertical section, ×18.

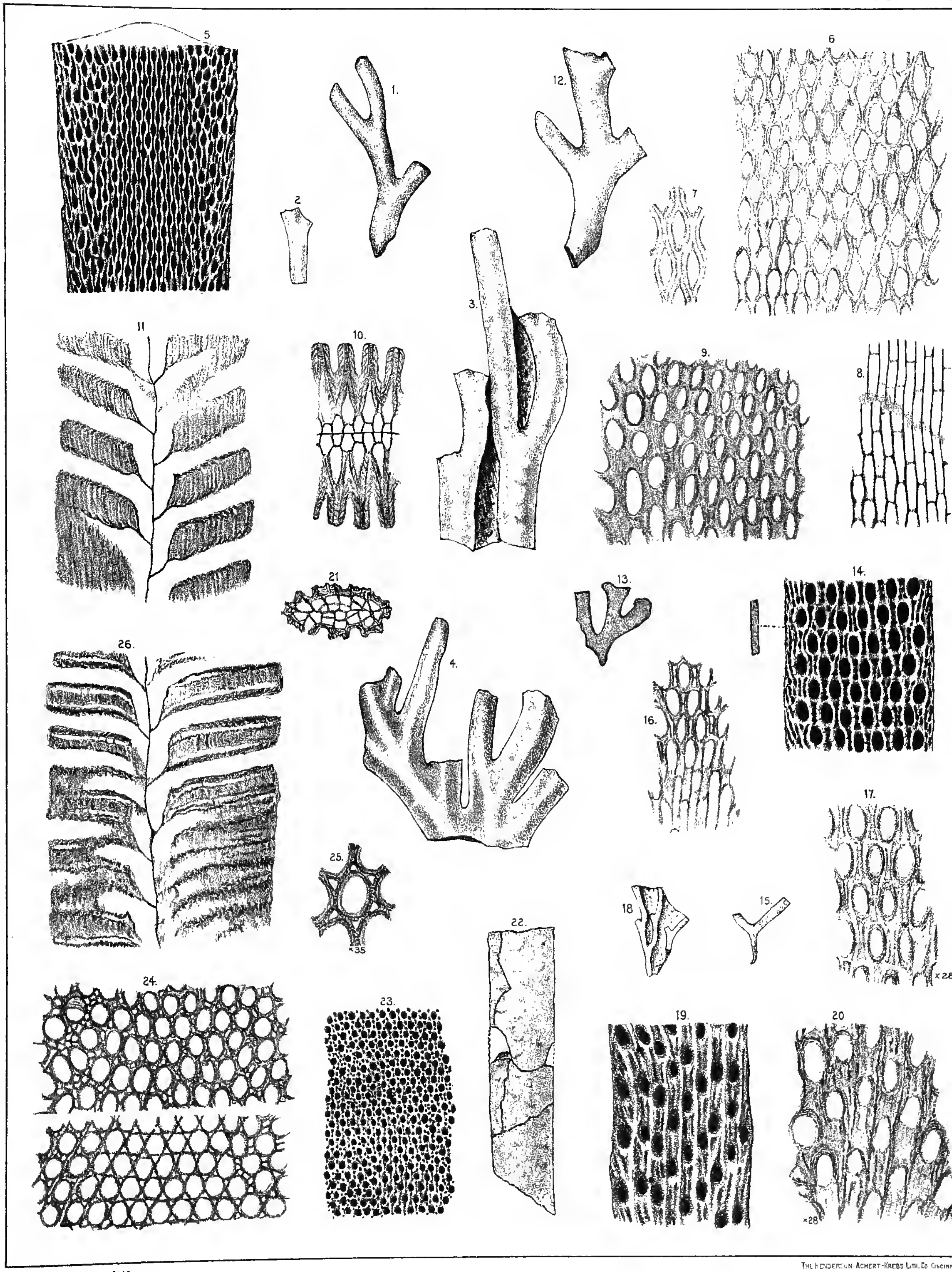
---

*The description of this interesting species having unfortunately been omitted from its proper place in the text, the following brief diagnosis of its peculiarities is added here:

Zoarium consisting of slender and frequently dividing branches, not exceeding 1.5 mm. in width; margins parallel, scarcely sharp. Zoœcial apertures oval, more or less oblique, arranged in eight or nine longitudinal rows, six or seven in 3 mm., between longitudinal ridges; diagonally three or four in 1 mm. End interspaces two or three times as long as the width of the space between the ridges, rsiing distally, usually with two elongate shallow pits or furrows.

All that is known of the interior is shown in the figures.

The types were collected at Montreal, Canada, in the Trenton limestone, by Mr. T. C. Curry, for the Peter Redpath Museum, from which institution they were obtained by the author in exchange for other fossils.



E.O.U del et lith.

The Henderson Achert-Krebs Lith. Co. Cincinnati

PLATE XIV.

PAGE

Figs. 1 to 8. PHYLLODICTYA VARIA, n. sp. 144

1. A fragment with subparallel margins, natural size.
2. Surface of same ×9.
3. Two rows of apertures ×18; shows the papillose character of the ridges.
4. Vertical section, ×18. By an oversight the diaphragms are wanting in this figure. Each tube should have one crossing it at right angles at a point about midway between its aperture and the mesial line.
5. Tangential section ×18. The internal characters are but illy preserved in even the best of the specimens sectioned.

6 and 7. Old zoarium of the natural size with a portion of its surface ×9. With age the maculæ become more distinct and the longitudinal arrangement of the zoœcial apertures less obvious.

8. Portion of a zoarium larger and wider than usual; natural size.

Middle third of the Trenton shales at Minneapolis.

Figs. 9 to 11. EURYDICTYA MULTIPORA (?Hall, sp.) 139

9. Fragment of a slightly undulating expansion, natural size.
10. Surface of same, ×9.
11. Small portion of same, ×18.

Upper third of the Trenton shales, St. Paul. Survey Museum, Reg. No. 5942.

Figs. 12 to 21. ARTHROPORA SIMPLEX Ulr. 177

12. Two segments of the usual size.

13 and 14. Two bifurcating segments, probably abnormal; natural size.

15. Several segments preserved in their natural positions, natural size.
16. Surface of a well preserved fragment, ×18.
17. Several zoœcial apertures of same, ×35. In many specimens the longitudinal prolongations from the ends of the inner ring of papillæ are longer, in some cases even joining.
18. Irregularly divided basal joint, natural size.
19. The lower part of same, ×9. It is difficult to make out the apertures, the whole surface appearing to be covered with closely intertwining striæ.
20. Vertical section, ×18. showing the form of the zoœcia, the hemisepta, and other features.
21. Three portions of a tangential section, ×35. In *a* the right hand third shows the structure just beneath the surface. In the middle third the section sinks to the level of the prostrate part of the zoœcia and in some of them both kinds of hemisepta are shown. On the left side the dark band represents the noncelluliferous margin. In *c* we have only the prostrate part of the zoœcia and the dense margin.

Middle third of the Trenton shales at Minneapolis.

Figs. 22 to 25. ARTHROPORA BIFURCATA, n. sp. 178

22. A small segment natural size and its upper part ×18.

23 and 24. Two old segments, the last one probably the basal, of the natural size.

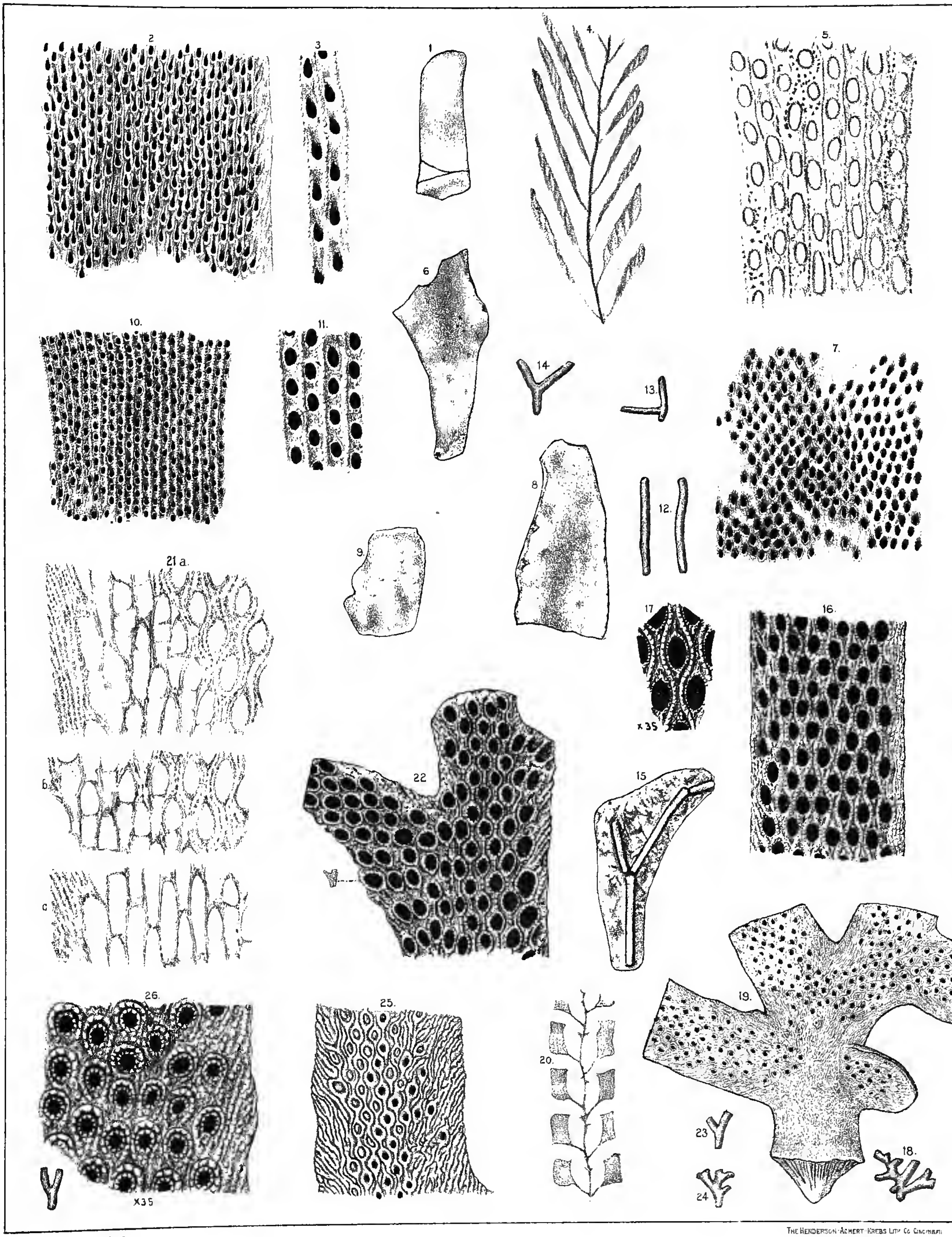
25. Surface of the original of fig. 23, ×18, illustrating the aged condition in contrast with the youthful stage represented in fig. 22.

Upper third of the Trenton shales, St. Paul.

Fig. 26. ARTHROPORA REVERSA, n. sp. 178

Natural size view of an average segment, and a portion of its surface ×35.

Base of the Galena shales at St. Paul.

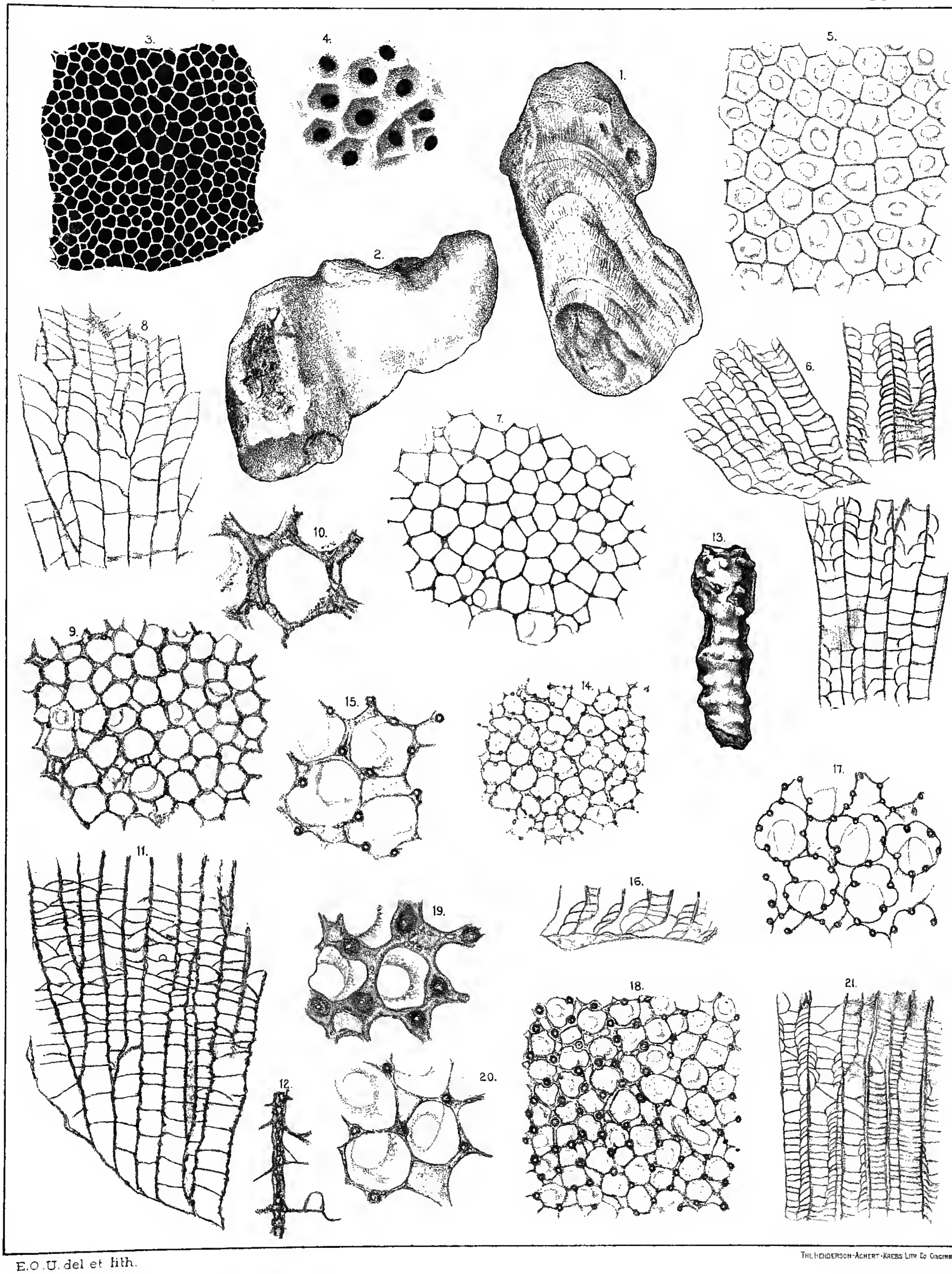


E. O. U del et lith.

THE HENDERSON-ACHERT-KREBS LITH Co. CINCINNATI.

PLATE XV.

PAGE



E.O.U. del et lith.

THE HENDERSON-ACHERT-KREBS LITH Co CINCINNATI.

PLATE XVI

PAGE

Figs. 1 to 10. PRASOPORA SIMULATRIX Ulr...... 24

1 and 6. Vertical and tangential sections, ×18, of a specimen of the var. *orientalis* from Trenton Falls, N. Y.

2 and 7. Similar sections of a Canadian (Ottawa) example of the same variety.

3 and 8. Similar sections of a Kentucky specimen of the western or typical form of the species.

4 and 9. Vertical and tangential sections of a specimen from the lower part of the Galena limestone at Mantorville, Minn. Mus. Reg. No. 5986.

5 and 10. Similar sections of another example of the typical form of the species from the upper third of the Trenton shales at St. Paul.

Figs. 11 to 15. PRASOPORA CONOIDEA Ulr.. 24

11 to 13. Lateral, basal, and one sectional view of three specimens of this species, natural size.

14. Tangential section ×18, showing the thin walls and minute acanthopores which are characteristic of the species.

15. Vertical section, ×18. The abundant tabulation of the tubes is the chief peculiarity brought out by this kind of section.

Upper third of the Trenton shales near Cannon Falls, Minn.

Figs 16 and 17. PRASOPORA SELWYNI Nicholson.. 25

16. Vertical section ×18, showing the isolation and semi-circular form of the cystiphragms.

17. Transverse section of same ×18.

Upper part of the Galena shales near Cannon Falls, Minn.

Figs. 18 and 19. PRASOPORA INSULARIS, var. FILLMORENSIS, n. var............................... 25

18. A tangential section ×18, showing the different appearance of the inter-zoœcial spaces when compared with typical *P. insularis*.

19. Small portion of a vertical section ×18, showing the vesicular character of the interspaces to which is due the difference referred to in the preceding paragraph.

Probably from the Trenton shales near Fountain, Minn.

Figs. 20 to 23. PRASOPORA INSULARIS, n. sp.. 251

20. Tangential section of an excellently preserved specimen, ×18.

21. Small portion of same ×50 to show the minutely cellulose character of the walls.

22. One zoœcial tube with adjacent mesopores and one wall with adjoining cystiphragms and diaphragms, ×18. In showing the much greater abundance of the cystiphragms and diaphragms when compared with other species of the genus, this figure, though small, is sufficient for the identification of the present species.

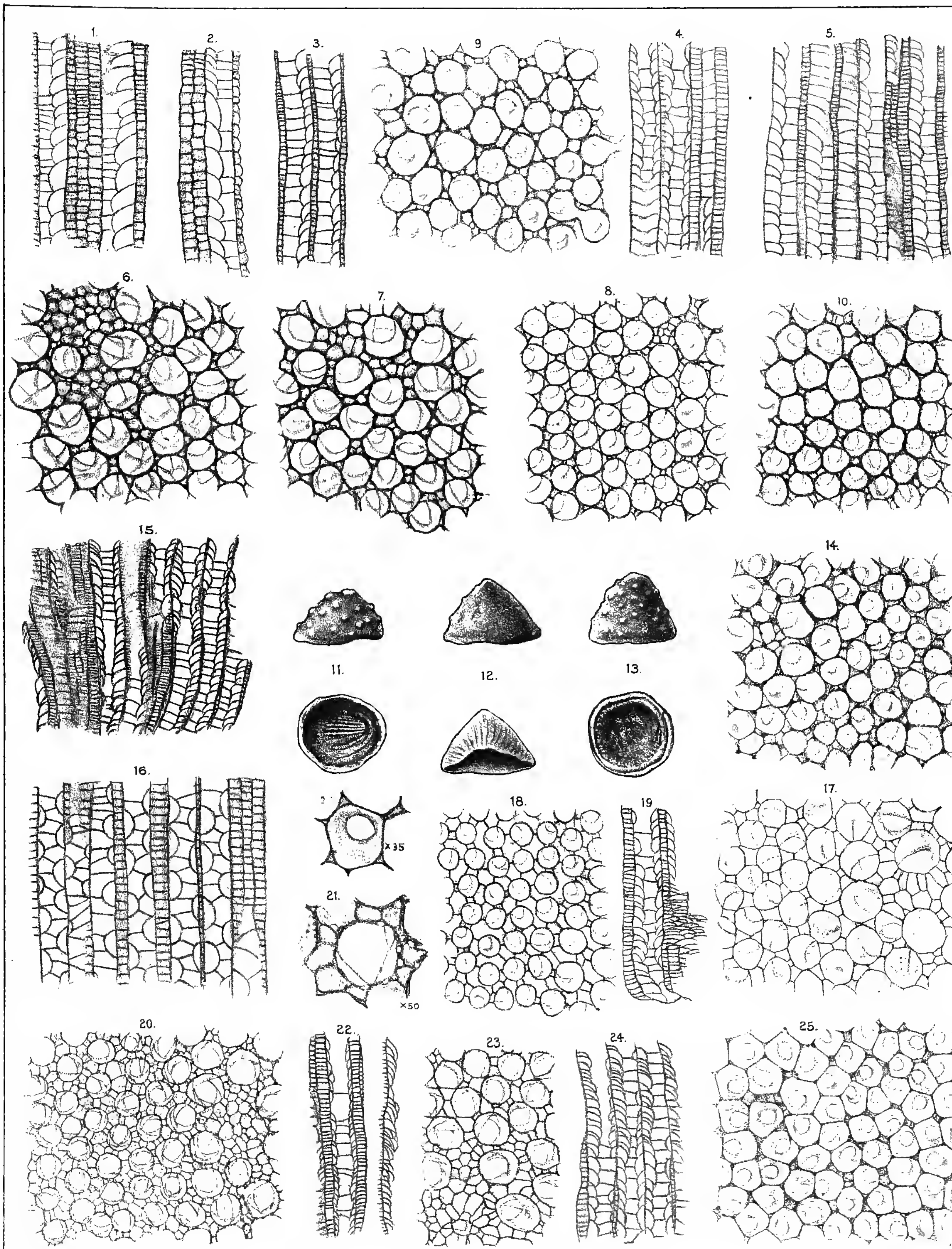
23. Small portion of another tangential section, ×18, in which the zoœcial tubes are more frequently in contact than in fig. 20.

Galena shales near Cannon Falls, Minn.

Figs. 24 to 26. PRASOPORA CONTIGUA Ulr.................... 24

24 and 25. Vertical and tangential sections, ×18, of a specimen from the upper part of the Trenton shales of Goodhue county, Minn.

26. One zoœcium and adjoining mesopores of same ×35. Mus. Reg. No. 5989.



E.O.U del et lith.

The Henderson Achert Krebs Lith. Co. Cincinnati

PLATE XVII.

PAGE

Figs. 1 to 8. MESOTRYPA INFIDA Ulr. 258

1 and 2. Two tangential sections prepared from the same example, ×18. The first illustrates the fully matured condition, the second an earlier level in the zoarium. Trenton shales near Fountain, Minn.

3 to 5. Three portions of a large vertical section of the same, ×18, showing the variable disposition and appearance of zoœcial diaphragms.

6. Portion of another vertical section of same ×18. Mus. Reg. No. 5993.

7. Surface of same, ×9, showing a condition approximately intermediate between figs. 1 and 2.

8. Surface of a parasitic specimen in a condition corresponding with fig. 1. Middle third of the Trenton shales, Minneapolis.

Figs. 9 to 12. MESOTRYPA (?) SPINOSA, n. sp. 259

9. Surface of well preserved example, showing the round form and regular arrangement of the zoœcial apertures, and the strong acanthopores; ×9.

10 and 11. Tangential section, ×18, and parts of several zoœcia ×50.

12. Small portion of a vertical section, ×18, showing unmistakable cystiphragms in the lower half. Other parts of the same section are like figs. 3 and 4 of this plate.

Middle third of the Trenton shales at St. Paul and Minneapolis.

Figs. 13 to 21. ASPIDOPORA ELEGANTULA, n. sp. 256

13. A fine example of this species on the surface of which an intermittent second layer of zoœcia was forming; natural size.

14. One of the areas of the secondary layer, ×9.

15. Tangential section prepared from the primary layer of same, ×18.

16 and 17. Views of the upper and lower sides of a specimen that consists of at least four distinct layers grown loosely over each other; natural size.

18. Upper surface of same, ×9.

19. Tangential section of one of the layers of same, ×18.

20. Parts of several zoœcia of a tangential section, ×50.

21. Several zoœcia and mesopores as seen in a vertical section of one of the layers, ×18.

Galena shales, Kenyon, Minn. These two specimens were collected by W. H. Scofield and kindly presented by him to the author.

Figs. 22 to 25. PRASOPORA LENTICULARIS, n. sp. 253

22. Upper surface and sectional view of an example of this species; natural size.

23. Two portions of a tangential section of same, ×18, the upper half representing the appearance in the upper third, the lower half that in the basal third of the zoarium.

24. One of the zoœcia and adjoining parts of same, ×50.

25. Vertical section of same, ×18, showing the comparatively loose tabulation of the two sets of tubes.

Upper third of the Trenton shales at St. Paul.

Figs. 26 to 32. ASPIDOPORA PARASITICA Ulr. 255

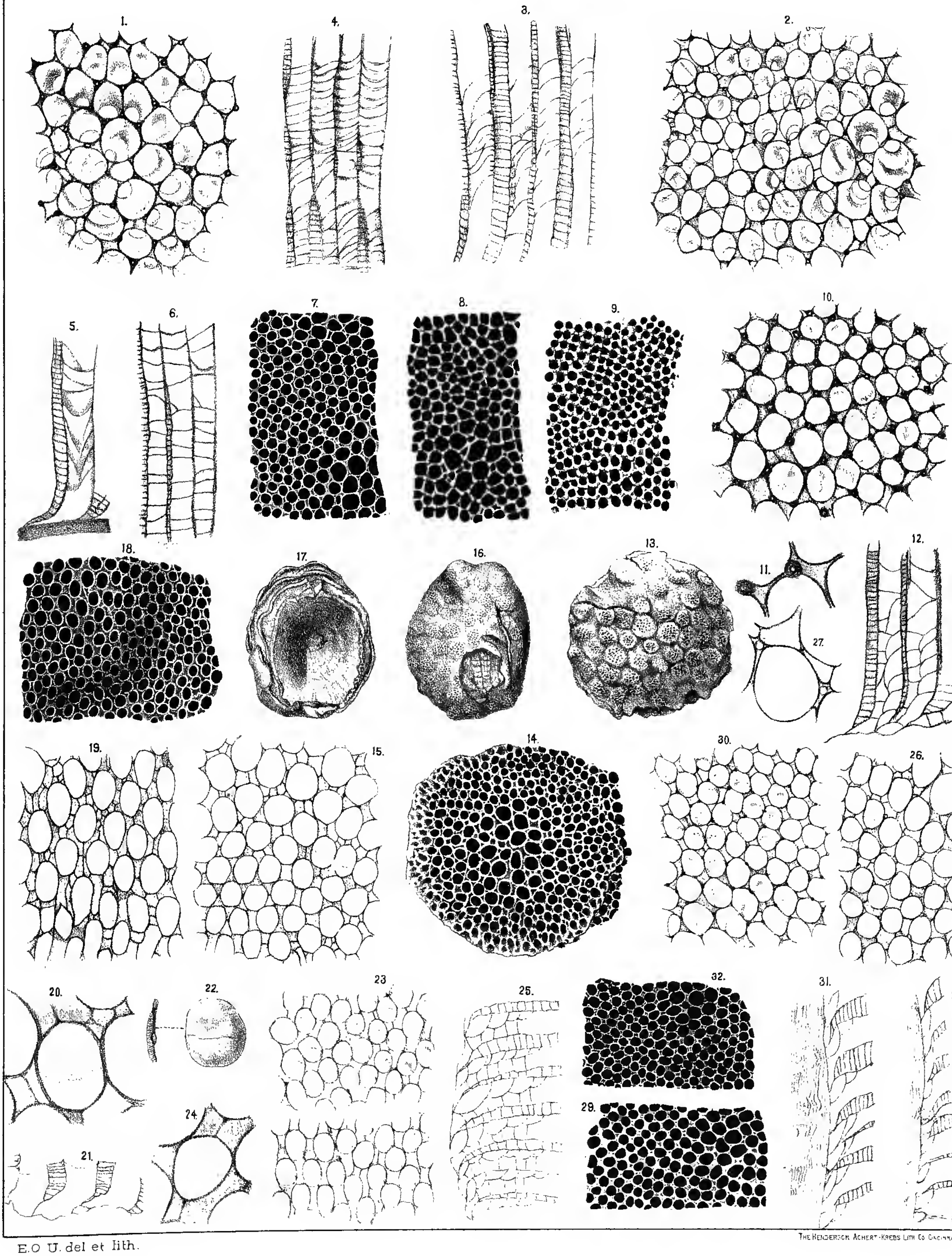
26 add 27. Portions of a tangential section, ×18 and ×50, with few cystiphragms and zoœcia very slightly larger than usual.

28. Vertical section of same specimen, ×18, showing entire thickness.

29. Surface of same, ×9.

30 to 32. Tangential and vertical sections, ×18, and the surface ×9, of a thicker zoarium.

Lower third of the Trenton shales, Minneapolis and near Fountain, Minn.



E.O U. del et lith.

THE HENDERSON ACHERT-KREBS LITH. CO. CINCINNATI

PLATE XVIII.

1 and 2. Tangential and vertical sections of a thick expansion, ×18.
3. Surface of well preserved specimen, ×18.
4. A montiferous variety attached to the shell of *Orthis subæquata* Conrad. (See also plate XV.)

Middle third of the Trenton shales, St. Paul.

5 and 6. Vertical and tangential sections of an example that is typical for the species in all respects excepting that the acanthopores are less numerous than usual; ×18. (See also plate XV.)

7 and 8. Tangential section and surface ×18, of a variety with larger zoœcia than the typical and common form of the species.

Middle third of the Trenton shales, Minneapolis.

9 to 11. Three fragments of the natural size, showing extremes in the size of the branches.
12. Surface of well preserved example ×18, with the mesopores open and distinctly visible and the walls thin.
13 and 15. Tangential and vertical sections ×18, prepared from the original of fig. 9. The walls are thick in the peripheral region and very few cystiphragms are noticeable in the tangential section.
14. Small portion of same tangential section ×50 to show the minute structure more clearly.
16. Central part of a transverse section of same specimen, ×18.
17 and 18. Vertical and tangential sections ×18, of a specimen with two series of cystiphragms, thinner walls, much larger maculæ, and more abundant acanthopores than the preceding.
19. Portion of one of the clusters of mesopores ×50.
20. Several zoœcia of the same tangential section ×50.

Middle third of the Trenton shales, St. Paul and Minneapolis.

21. Tangential section ×18, showing, among other peculiarities of the species, the abundance of the mesopores.
22. Peripheral part of a vertical section ×18, showing the comparatively remote tabulation of the tubes.

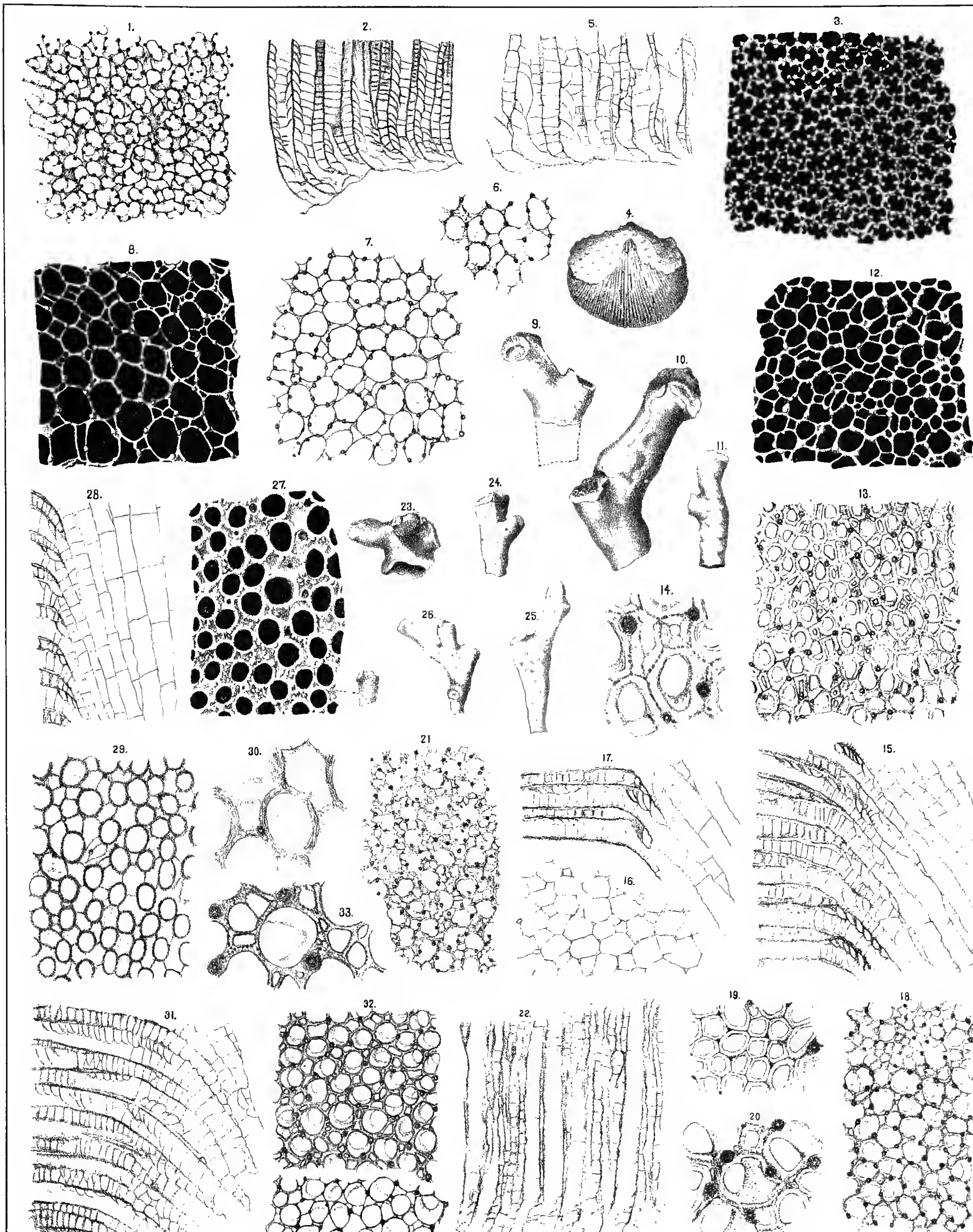
Middle third of the Trenton shales, St. Paul.

23 to 26. The basal part of a zoarium and three representative branches of the natural size.
27. Well preserved fragment of the natural size and a portion of its surface ×18.
28 and 29. Vertical and tangential sections ×18.
30. One zoœcium and adjacent parts of the tangential section, ×50.

Galena shales near Cannon Falls, Minn.

31. Vertical section ×18.
32. Two portions of a tangential section ×18, the upper part giving the appearance immediately beneath the surface while the lower represents a deeper level.
33. Small portion of the mature region of the tangential section ×50.

Upper part of the Hudson River group near Spring Valley, Minn.



E.O.U. del et lith.

THE HENDERSON-ACHERT-KREBS LITH. CO. CINCINNATI

PLATE XIX.

PAGE

Figs. 1 to 9. HOMOTRYPA MINNESOTENSIS Ulr.... 235

1 to 3. Vertical, transverse and tangential sections ×18, of a specimen having the walls in the peripheral region thicker than usual. Mus. Reg. No. 5970.

3*a*. Small portion of a tangential section of an example of the var. *montifera*, ×50. Base of the upper third of the Trenton shales at St. Paul.

4 and 5. Tangential and vertical sections of an average specimen, ×18.

6. The peripheral part of two zoœcial tubes, ×18, more closely tabulated than usual. Mus. Reg. No. 5970*b*.

7 and 8. Two examples of the natural size. The end view under the latter shows the exceeding narrowness of the peripheral region.

9. Surface of the original of fig. 7, ×9.

Lower third of the Trenton shales, Minneapolis.

Figs 10 to 16. HOMOTRYPA EXILIS Ulr.. 236

10 and 11. Two fragments of the natural size.

12. Vertical section ×18.

13. Tangential section in a pre-mature condition, ×18.

14. Tangential section showing fully matured characters, ×18.

15. Portion of fig. 14 more highly magnified.

16. Portion of fig. 13 more highly magnified.

Lower third of the Trenton shales at Minneapolis.

Figs. 17 to 20. HOMOTRYPA SEPARATA, n sp.................. 237

17 and 18. Tangential section of this peculiar species, ×18, and a portion of same ×50.

19. Surface of a well marked specimen ×9.

20. Vertical section ×18. Attention is to be directed to the tabulated interstitial spaces.

Lower third of the Trenton shales, Minneapolis.

Figs. 21 to 28. HOMOTRYPA SUBRAMOSA Ulr............ 239

21. View of a characteristic specimen showing the irregular division of the branches.

22, 24 and 25. A series of three tangential sections ×18, agreeing in all respects except that while in the first the acanthopores are numerous and well developed they are fewer in the second and quite inconspicuous in the third. Original of fig. 24 belongs to Survey Museum, Reg. No. 5980*a*.

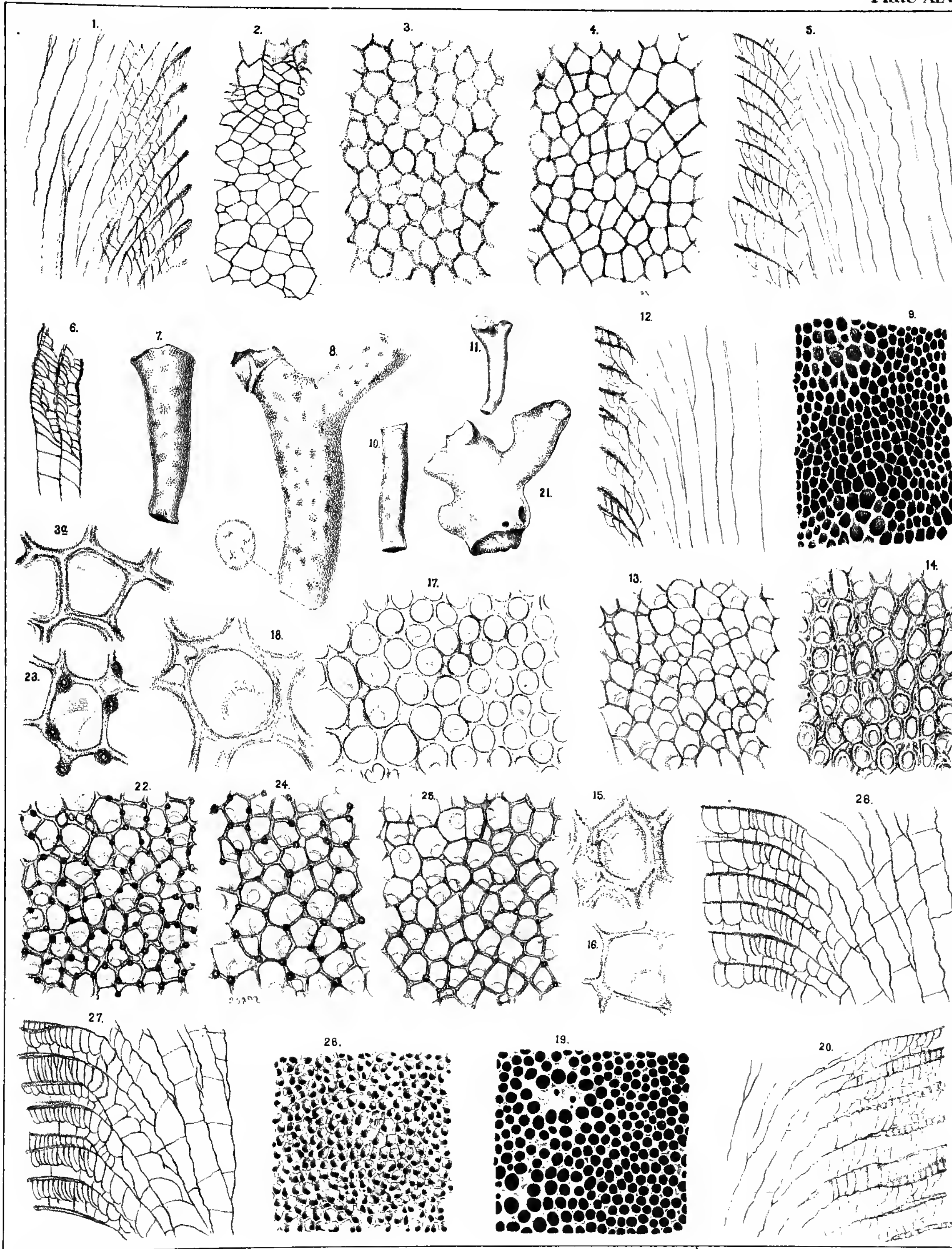
23. Small portion of fig. 22 more highly magnified.

26. Vertical section ×18, of a specimen having the outermost region loosely tabulated; very unusual. Mus. Reg. No. 5980*b*.

27. Vertical section of a typical example, ×18.

28. Surface of an average example, showing the cystiphragms in the zoœcial apertures, ×9.

Upper third of the Trenton shales, St. Paul and near Cannon Falls.



E.O.U. del. et lith.

The Henderson-Achert-Krebs Lith. Co. Cincinnati.

PLATE XX.

PAGE

Figs. 1 to 9, 13 and 14. MONTICULIPORA ARBOREA, n. sp. 22

1. Peripheral part of a vertical section ×18.
2. Several tubes from the axial region of same ×18, showing the presence of cystiphragms in even this portion of the zoarium.
3. Transverse section from the center to the periphery of a branch ×18, proving the presence of cystiphragms throughout.

4 and 5. Fully matured portion of a tangential section ×18 and a small part of same ×50.

6. Shows the appearance at a slightly lower level than fig. 4.
7. Small portion of the surface of the specimen represented by fig. 8; ×9.

8 and 9. Two fragments of the natural size exhibiting a difference in the prominence of the monticules.

Galena shales near Cannon Falls, Minn.

13 and 14. Tangential and vertical sections of a form of the species from the Trenton at Burgin, Ky.; ×18.

Figs. 10 to 12. MONTICULIPORA (?) CANNONENSIS, n. sp. 22

10 and 11. Vertical and tangential sections ×18.

12. One zoœcium ×50.

Galena shales near Cannon Falls, Minn.

Figs. 15 to 21. HOMOTRYPA CALLOSA, n. sp. 24

15 and 16. Tangential section×18 and a small portion of same ×50, of a specimen from the Galena shales near Cannon Falls.

17. Vertical section of same ×18.

18 and 19. Peripheral and axial portions of a vertical section ×18, prepared from a specimen from the Trenton at Burgin, Ky.

20 and 21. Tangential section of same ×18 and ×50, differing slightly from that of the Minnesota form.

Figs. 22 to 27. ATACTOPORELLA RAMOSA, n. sp. 22

22. Two portions of a tangential section ×18, exhibiting differences that depend upon the varying depth at which the section passes through the zoarium.
23. Small portion of same more highly magnified.
24. Axial region of a transverse section ×18.
25. Vertical section ×18, showing the continuance of the series of cystiphragms into the axial region.

26 and 27. Two specimens of the natural size.

Upper third of the Trenton shales near Cannon Falls, Minn.

Figs 28 to 33. HOMOTRYPA SIMILIS Foord* 24

28. Portion of the peripheral third of a transverse section ×18, Cannon Falls.
29. Vertical section of an authentic Canadian example of the species ×18.
30. Two portions of a tangential section of same ×18.

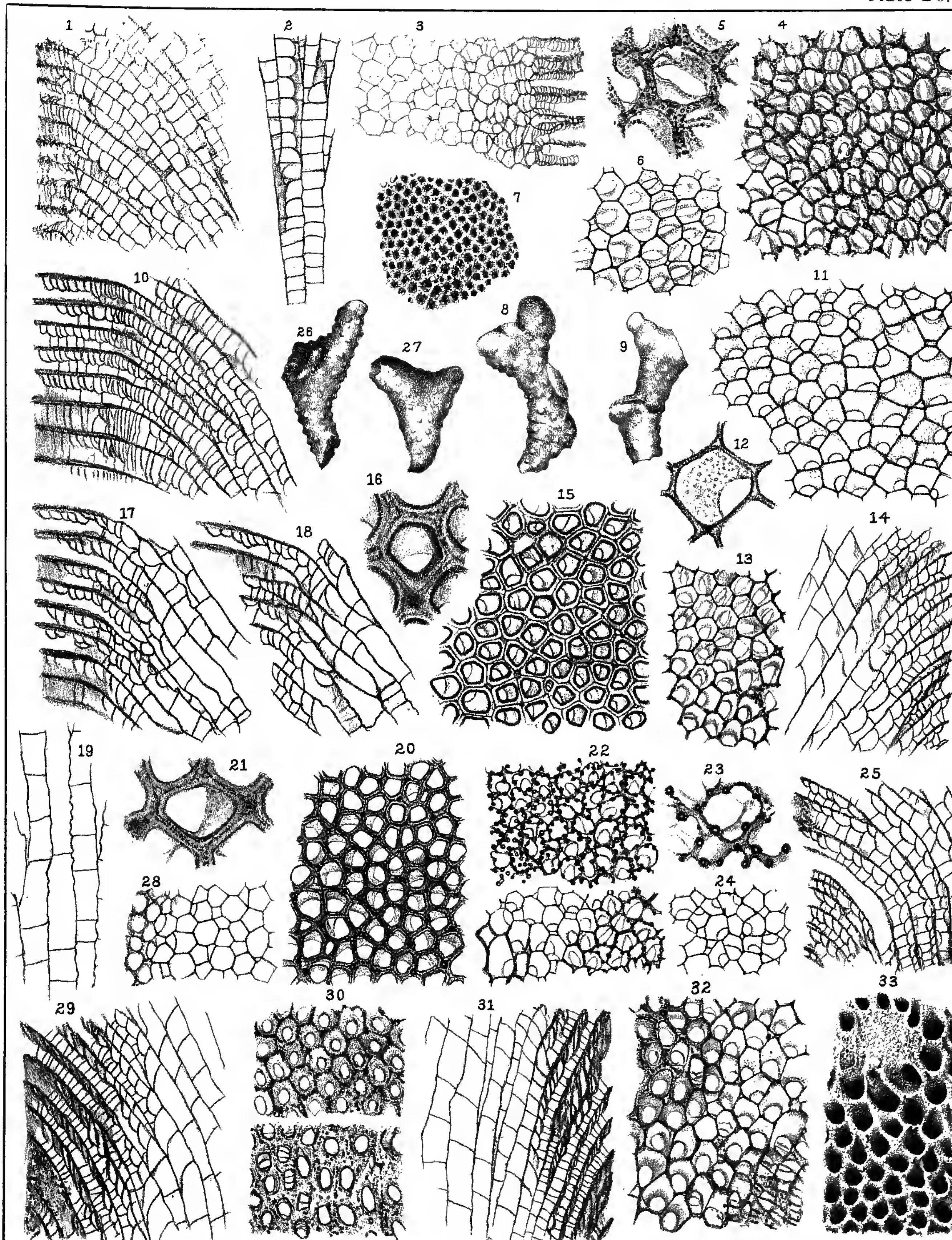
31 and 32. Vertical and tangential sections of a Minnesota specimen, ×18.

33. Surface of another specimen from this state ×18.

Trenton limestone Ottawa, Can., and upper part of the Galena shales near Cannon Falls, Minn.

---

*The systematic position of this species is doubtful. Though falling in a loose way under *Homotrypa* some of its characters are so peculiar that it can in no wise be regarded as a true representative of the genus. Thin sections are suggestively like those of *Homotrypella instabilis* and in some features also simulate those of *Eridotrypa mutabilis*.



E.O.U. del. et lith.

MACBRAIR LITH. CO. CIN. O

PLATE XXI.

PAGE.

Figs. 1 to 7. CONSTELLARIA VARIA, n. sp. .... 31[?]

1. Surface of a mature example, ×9, with wide interspaces and correspondingly narrow zoœcial apertures.
2. Surface, ×18, of another example showing a less matured stage than fig. 1, the interspaces being thinner and the zoœcial apertures larger.
3. Tangential section, ×18, showing appearances immediately beneath the surface of an old specimen. At deeper levels the walls are thinner and the interspaces narrower.
4. Small portion of preceding, ×50, with two of the minute mural tubuli.
5. Vertical section of an average specimen, ×18.

6 and 7. Two fragments of the natural size, one very small, the other of medium dimensions.

Galena shales near Cannon Falls, Minn.

Figs. 8 to 12. NICHOLSONELLA PULCHRA, n. sp. 314

8. An unusually wide fragment of the natural size.
9. Surface of same, ×9.
10. Two portions of a tangential section, ×18, the upper illustrating the appearance just beneath the surface of a mature example, the lower at a deeper level.
11. Vertical section of same, ×18.
12. Central portion of a transverse section, ×18.

"Pierce limestone", Murfreesboro, Tenn.

Figs. 13, 14, 20 and 22. NICHOLSONELLA PONDEROSA ? Ulrich 316

13. Two portions of a tangential section, ×18. In the original the details are obscure and it is probable that the interstitial dots are too numerous and small.
20. Small portion of the peripheral part of a vertical section, ×18. The structure is but illy preserved in these sections.
14. Two portions of a tangential section of another specimen, ×18, the upper immediately beneath the surface.
22. From the peripheral part of a transverse section of same, ×18.

Lower third of the Trenton shales, Minneapolis.

Figs. 15 to 19 and 21. NICHOLSONELLA LAMINATA, n. sp. 315

15. Tangential section of specimen in an unusually good state of preservation, ×18.

16 and 17. Portions of same ×50.

18 and 19. Under side of a fragment, nat. size, and the upper surface ×9. In this specimen the mesopores are shown much more clearly than in others.

21. Small portion of a vertical section, ×18, passing through one of the maculæ.

Middle third of the Trenton shales, Minneapolis.

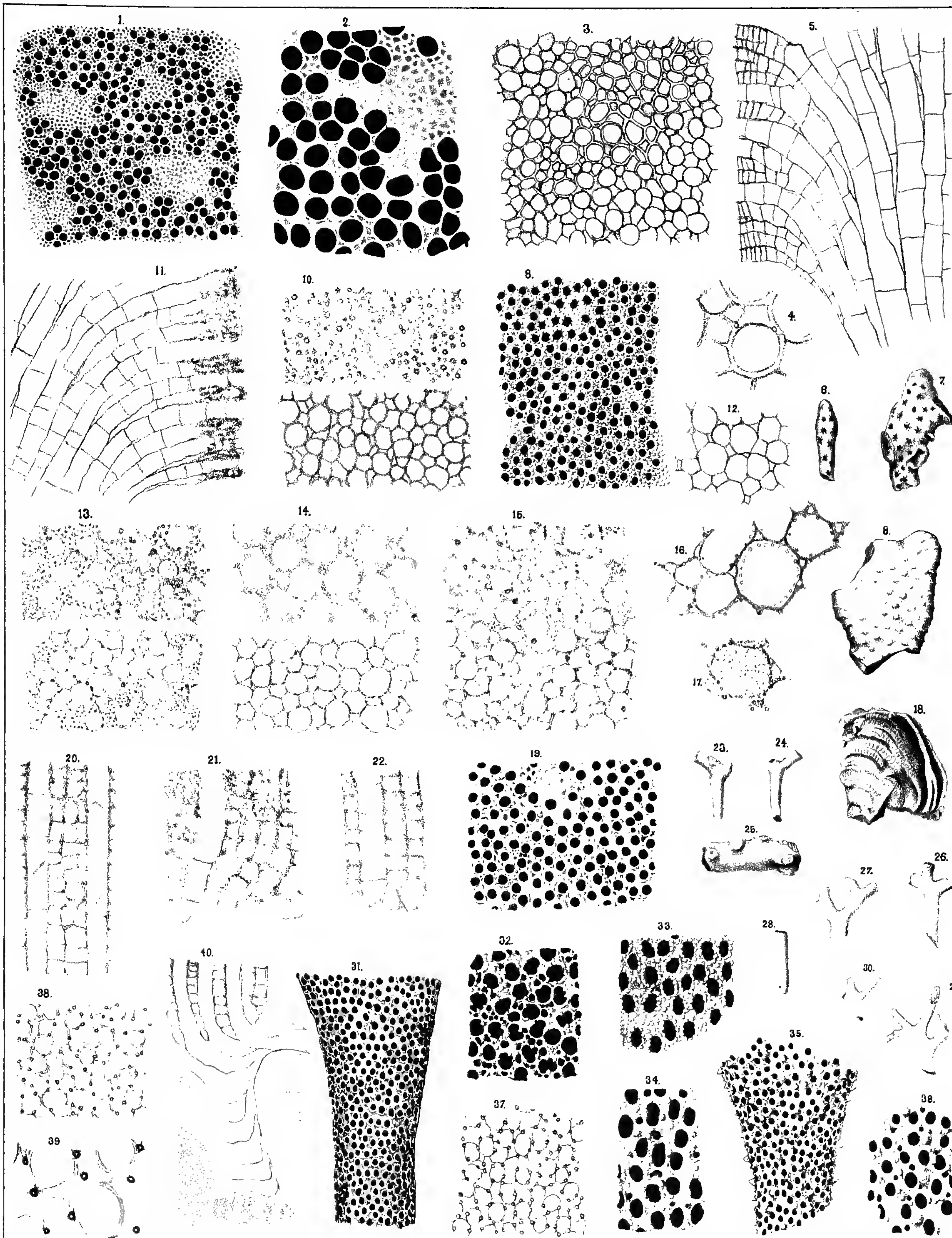
Figs. 23 to 40. TREMATOPORA ? PRIMIGENIA (and varieties) Ulrich .... 30[?]

23 to 27. Fragments of the typical form.

28 and 33. Original type of *T. ornata* and surface of same ×18.

29. A large specimen of var. *spinosa ;* 30, a smaller and better preserved fragment; 35, surface of the latter, ×9; 36, small portion of same ×18.
31. Surface, ×9, of an average example of the typical form. No attempt has been made to draw the small acanthopores.
32. Surface of specimen with acanthopores unusually abundant and inflecting the zoœcial apertures, ×18. The specimen is peculiar also in having many of the mesopores open.
34. Original of fig. 26, ×18, (var. *ornata*) with spines and occasional open pores in the inter spaces.
37. Tangential section, ×18, from a specimen whose surface is drawn in fig. 32.
38. More common appearance of typical tangential sections, ×18.
39. Small part of preceding ×50.
40. Vertical section of basal expansion, ×18. It is attached to a crinoid column and shows how the tubes grew into the depressions between the rings and failed to attain maturity.

Middle third of the Trenton shales, Minneapolis.



E.O.U del et lith.

The Henderson Achert Krebs Lith. Co. Cincinnati.

PLATE XXII.

PAGE

Figs. 1 to 12. CALLOPORA PULCHELLA, n. sp. 28

1 to 3. Three typical specimens of the natural size.
4. Surface of the original of fig. 3 ×9.
5. One of the depressed spaces of same ×18.
6 and 7. Two fragments, one unusually slender the other thicker than usual.
8. Portion of the original of fig. 7 where the walls are thinner and the mesopores larger than usual, ×18. Other parts of its surface more as shown in fig. 5.
9. Vertical section ×18.
10 and 11. Average tangential section ×18 and small portion of same ×50.
12. Transverse section, natural size and one fifth of it ×18. Note comparatively small size of the tubes in the axial region and wide peripheral region.

Upper third of the Trenton shales, St. Paul.

Figs. 13 to 17. CALLOPORA PULCHELLA, var. PERSIMILIS, n. var. 284

13. Two fragments showing the exceeding prominence of the monticules.
14. Portion of the surface between the monticules ×18.
15 and 16. Vertical and tangential sections ×18.
17. A transverse section, natural size and portion of same ×18.

Upper third of the Trenton shales near Cannon Falls.

Figs. 18 to 23. CALLOPORA CRENULATA, n. sp. 284

18. A fragment of the zoarium of this species, natural size.
19. Surface of same ×9.
20. Average tangential section ×18. Another, representing a more matured condition, rather closely resembles fig. 10.
21. Vertical section ×18.
22. Several tubes from the axial region of same ×18, showing the wavy character of the walls.
23. Portion of one of the maculæ and adjacent parts of a specimen that preserves the centrally perforated zoœcial closures, ×18.

Upper third of the Trenton shales, St. Paul.

Figs. 24 to 31. CALLOPORA UNDULATA Ulr. 279

24 and 25. Typical specimens of the natural size.
26. A fragment with rounded monticules. These are too prominent in the figure.
27. Nearly smooth fragment, in this respect approaching *C. incontroversa.*
28. Surface of the original of fig. 25, ×9.
29. Tangential section ×18.
30. Portion of a transverse section ×18.
31. Vertical section ×18.

Middle third of the Trenton shales, St. Paul and Minneapolis.

Figs. 33 to 36. CALLOPORA INCONTROVERSA Ulr. 278

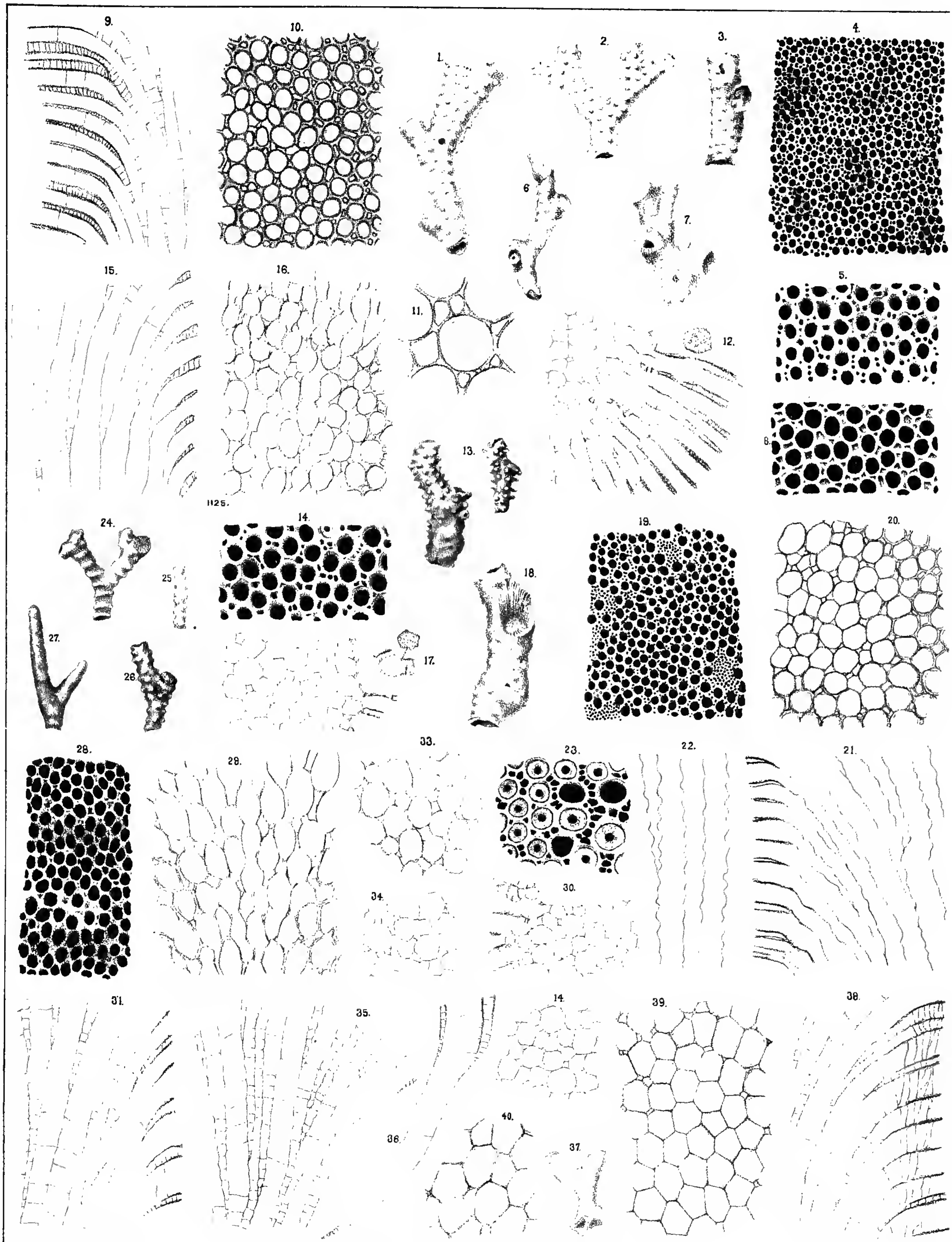
33. Tangential section ×18, representing part of one of the clusters of large zoœcia and a few of those of the ordinary size. Compared with *C. undulata* (fig. 29) it will be noticed that they are of more rounded shape.
34. The central part of a transverse section ×18
35. The axial part of a vertical section ×18. At the right upper corner one of the tubes is drawn to its aperture.
36. An entire but rather short zoœcial tube ×18, showing the distribution of the diaphragms.

Lower third of the trenton shales, Minneapolis.

Figs. 37 to 41. CALLOPORA ANGULARIS, n. sp. 277

37. Fragment of the natural size.
38. Vertical section ×18.
39. Tangential section showing fully matured characters, ×18.
40. Small portion of another tangential section ×18 showing the slightly irregular character of the cells at a deeper level in the zoarium than that represented in fig. 39.
41. (14 on some of the plates.) Axial region of a transverse section ×18.

Lower third of the Trenton shales, Minneapolis.



E.O.U. del et lith.

THE HENDERSON ACHERT-KREBS LITH CO CINCINNATI

PLATE XXIII.

PAGE.

Figs. 1 to 8. CALLOPORA DUMALIS, n. sp. 28

1 to 4. Representative fragments of the natural size.
5. Surface of the slender piece ×9.
6. Surface of another that preserves the zoœcial closures, ×18.
7 and 8. Vertical and tangential sections ×18.
Upper third of the Trenton shales, St. Paul.

Figs. 9, 10, 21 and 29. CALLOPORA GOODHUENSIS, n. sp. 28

9 and 10. Two fragments of the natural size.
21. Axial region of a transverse section ×18.
29. Surface of a specimen ×9.
Galena shales near Cannon Falls, Minn.

Figs. 11, 12, 16, 17, 24-26, 30, 31. CALLOPORA MULTITABULATA Ulr. 280

11 and 12. Montiferous examples, the latter but slightly, from the Galena shales at Cannon Falls.
16. Typical specimen from the upper third of the Trenton shales at St. Paul.
17. Tangential section ×18, of the Galena shales form.
24. Vertical section of a specimen like fig 16, ×9.
25. Surface of the original of fig. 16, ×9.
26. Surface of a very finely preserved specimen ×18, showing the ornamental zoœcial closures. Upper third of the Trenton shales, St. Paul.
30. Surface of a specimen like the one from which the illustrated tangential section (fig 17) was prepared, ×9. The figure includes one of the clusters of large zoœcia.
31. Surface of a typical specimen ×9.

Figs. 13-15, 18-20, 22, 23, 27, 28. CALLOPORA AMPLA, n. sp. 281

13. A large irregular specimen from the Galena shales at Cannon Falls.
14 and 15. Two typical examples from the base of the upper third of the Trenton shales near Fountain, Minn.
18. Tangential section ×18, of another specimen from the same horizon and locality as the preceding.
19. Vertical section of the same ×9.
20. The axial region of a transverse section of the same ×18.
22 and 23. Portion of one zoœcial tube of a vertical section and a tangential section, ×18, of a specimen like figs. 13 and 28. Galena shales, Cannon Falls.
27. Surface of the original of fig. 14, ×9.
28. Surface of the original of fig. 13, ×9.

Figs. 32 to 47. DEKAYELLA PRÆNUNTIA, n. sp., and varieties.

Figs. 32 to 38. Var. ECHINATA, n. var. 27

32. Typical example of this variety.
33 and 34. A less compressed fragment of the natural size and a portion of its surface ×9.
35 and 36. Two portions of a tangential section ×18.
37. Vertical section of the same specimen ×9.
Lower part of the upper third of the Trenton shales near Fountain, Minn.
38. Portion of a tangential section of a specimen from the upper part of the middle third of the Trenton shales at Minneapolis; ×18. Other parts of this section are precisely as in fig. 36, but in the portion figured the mesopores are larger and more abundant than usual for this variety. The vertical section of this specimen is indistinguishable from fig. 37.

Figs. 39 to 42. Var. SIMPLEX, n, var. 27

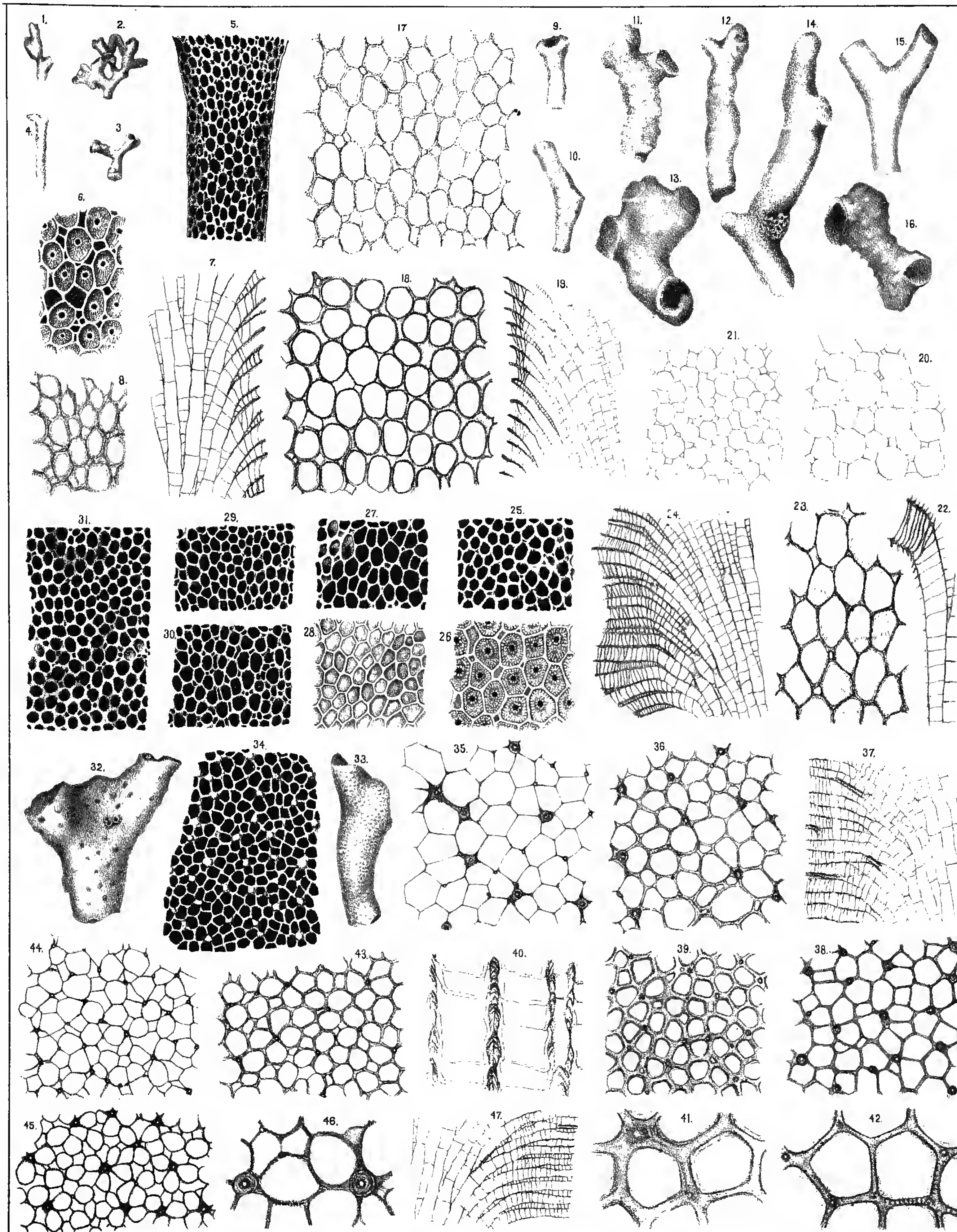
39. Tangential section ×18, of a specimen with thick walls.
40. Very small portion of the superficial region of a vertical section magnified 50 diameters to show the minute structure of the walls and the method of depositing the diaphragms.
41 and 42. Small portions of two tangential sections ×50, the first with walls as in figs. 39 and 40, the second with thinner walls, parts of which are marked transversely.
Lower third of the Trenton shales, Minneapolis.

Fig. 43. The TYPICAL FORM of the species. 27

An average tangential section ×18. Middle third of the Trenton shales at Minneapolis.

Figs. 44 to 47. Var. MULTIPORA, n. var. 27

44. A tangential section ×18, with very thin walls and small acanthopores.
45 and 46. Another tangential section with stronger walls and large acanthopores, ×18, and several cells ×50.
47. Vertical section ×18.
Middle third of the Trenton shales, Minneapolis.



E.O.U del et lith.

THE HENDERSON ACHEPT-KREBS LITH Co CINCINNATI

PLATE XXIV.

PAGE.

Fig. 1 to 4. HEMIPHRAGMA OTTAWENSE (Foord) 30

1 and 2. Two portions of a tangential section ×18, showing differences due to age.

3. Vertical section ×9.

4. Small portion of the peripheral region of the same ×35.

Upper part of the Galena shales, Mantorville, Minn. Survey Museum, Reg. No. 6002.

Figs. 5 to 19. HEMIPHRAGMA IRRASUM Ulr. 29

5. Vertical section ×9.

6, 7, 9 and 14. Four tangential sections ×18, exhibiting individual variations.

8. Small part of a transverse section ×18.

10 to 13. The surfaces of four specimens ×9, fig. 10 representing a good average, fig. 12 the appearance of young examples, and figs. 11 and 13 the fully matured conditions.

15 to 19. A group of five specimens, three of them of the average size, while 17 is the largest and 18 one of the smallest seen.

Lower third of the Trenton shales at Minneapolis, and the Galena shales near Cannon Falls, Minn.

Figs. 20 to 23. HEMIPHRAGMA TENUIMURALE, n. sp. 30

20. Vertical section ×18.

21 and 22. Tangential sections ×18, the first showing the fully matured condition, the second a younger stage in the development of the zoarium.

23. Surface of a well preserved example showing the incomplete diaphragms in the zoœcial cavities, ×9.

Galena shales near Cannon Falls.

Figs. 24 to 31. STROMATOTRYPA OVATA, n. sp. 30

24. Surface of an old example ×9.

25, Well preserved specimen consisting of several layers, natural size.

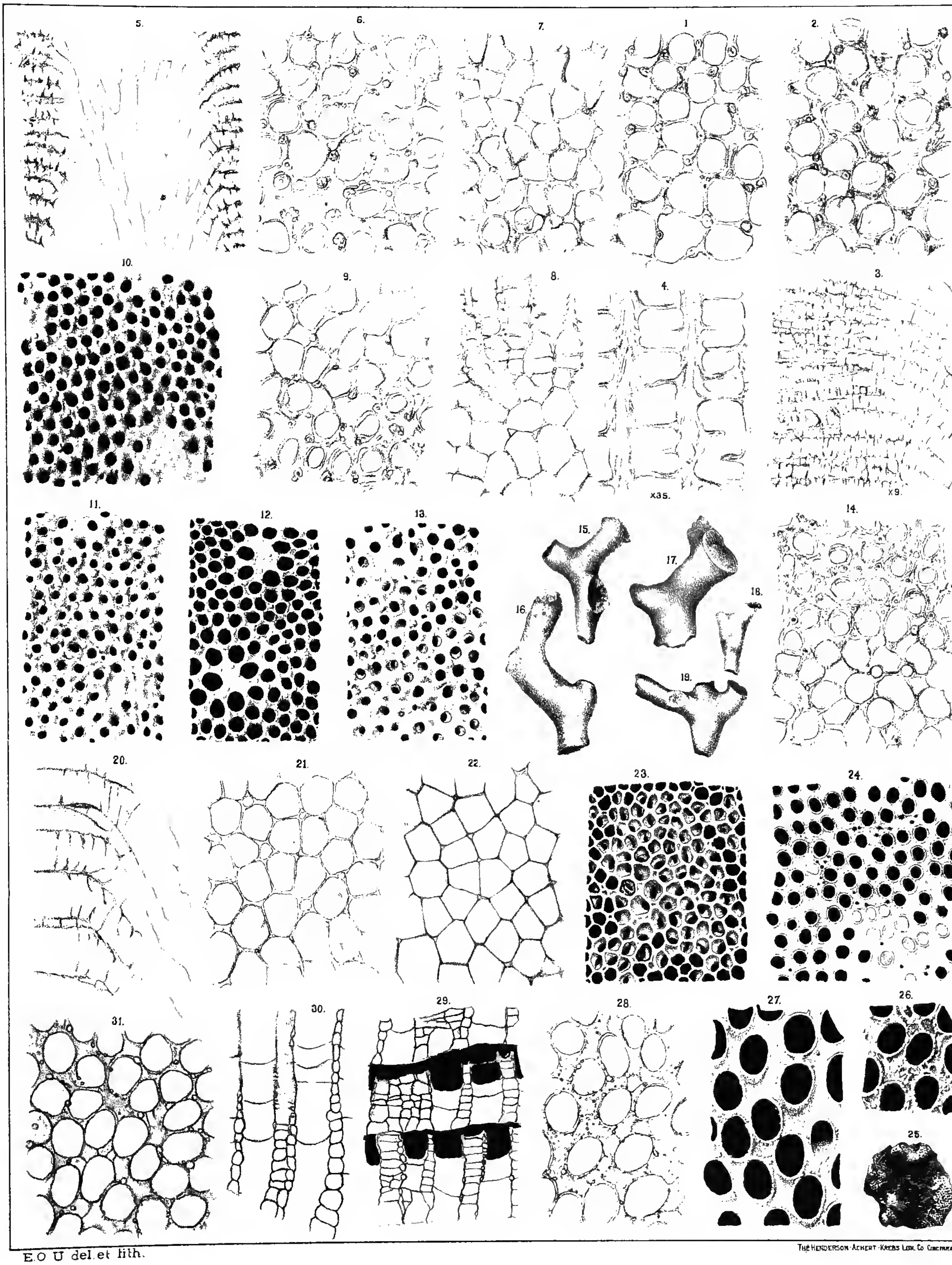
26. Small portion of one of the first layers of same ×18, showing an aged condition.

27. Part of the last layer of same ×18, showing appearance of surface in the youngest stage observed.

28 and 29. Tangential and vertical sections ×18, of an example consisting of three distinct layers of zoœcia

30 and 31. Another pair of sections, vertical and tangential, the latter illustrating a more aged condition than is shown in fig. 28; ×18.

Middle third of the Trenton shales, St. Paul and Minneapolis.



E. O. U. del. et lith.

THE HENDERSON-ACHERT-KREBS LITH. CO. CINCINNATI

PLATE XXV.

PAGE

Figs. 1 to 11. BATOSTOMA FERTILE Ulr. 29
- 1 and 2. A small and a large specimen.
- 3. Surface of the larger specimen, which is a typical example of the species, ×9.
- 4. Tangential section, prepared from the same specimen, ×18.
- 5 and 6. Surface of the var. *circulare* ×9 and ×18.
- 7. Tangential section of a specimen with very thin walls and exceedingly small acanthopores, ×18. The shaded spaces are mesopores.
- 8 and 9. Tangential sections of two specimens of the var. *circulare*, ×18, the first with very thick wall, the second with them thinner and in this respect agreeing with figs. 5 and 6.
- 10. Portion of the axial region of a transverse section of a typical specimen, ×18.
- 11. Vertical section of the natural size and a portion of same ×18; typical.

Lower third of the Trenton shales, Minneapolis.

Figs. 12 to 15. BATOSTOMA MAGNOPORA, n. sp. 29
- 12. A rather small specimen of the natural size.
- 13. Tangential section ×18.
- 14. Part of the axial region of a transverse section ×18.
- 15. Vertical section ×9.

Middle third of the Trenton shales, Minneapolis and St. Paul.

Figs. 16 to 25. BATOSTOMA VARIUM, n. sp. 29
- 16 to 22. Seven figures illustrating the extreme variability displayed by tangential sections of this species; ×18. Figs. 16 and 17 represent different parts of the same section, 18 shows the tubes just after bending out of the axial region, 16, 19 and 20 are of common occurrence, and 21 and 22 show extremes rarely met with.
- 23 and 24. Halves of two vertical sections ×9, the first normal, the second indicating some disturbance in the development of the tubes.
- 25. One zoœcial tube of a vertical section of the basal expansion ×18.

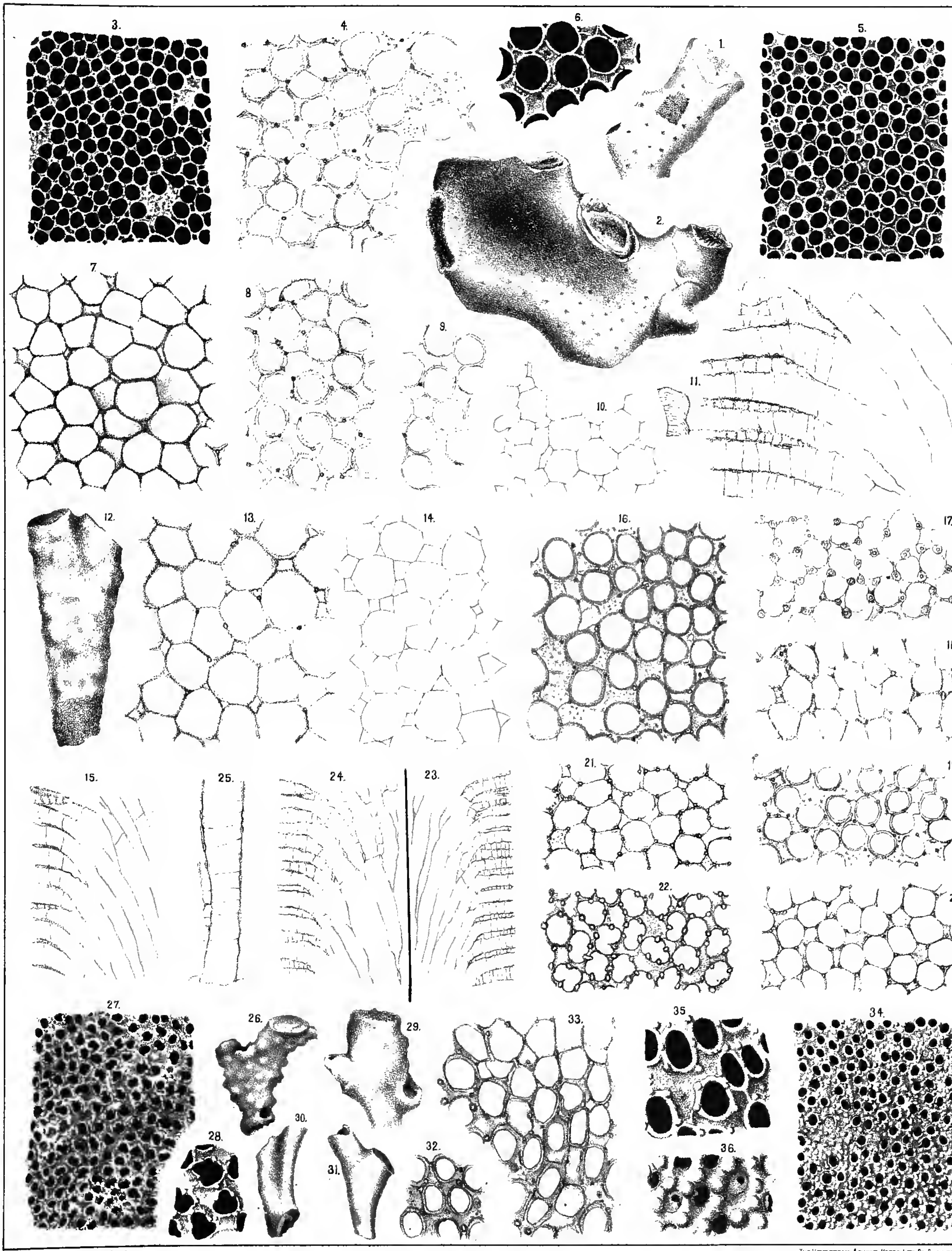
Middle third of the Trenton shales at St. Paul and Minneapolis.

Figs. 26 to 28. BATOSTOMA MONTUOSUM, n. sp. 29
- 26. An average specimen of the natural size.
- 27 and 28. Surface of a specimen with numerous closed mesopores ×9 and a small portion of same ×18. In many specimens the interspaces are narrower than is shown in these figures.

Upper third of the Trenton shales near Cannon Falls, Minnesota.

Figs. 29 to 36. BATOSTOMA HUMILE, n. sp. 29
- 29 to 31. Three fragments of the natural size.
- 32. Small portion of a tangential section ×18, of a specimen having a surface like fig. 34.
- 33. Tangential section of a less matured example ×18.
- 34. Surface of an average fully matured example ×9.
- 35. Surface of a young example (corresponds to the lower part of fig. 33) ×18.
- 36. Surface of a fragment regarded as illustating a condition of extreme age, ×18.

Galena shales near Cannon Falls, Minn.



E.O.U del et lith.

The Henderson-Achert-Krebs Lith Co. Cincinnati

PLATE XXVI.

PAGE.

Figs. 1 to 6. BYTHOPORA HERRICKI Ulr 26

1. Vertical section ×18, showing slight irregularity in the growth.

2 and 3. Tangential section ×18 and a portion of same ×50.

4 and 5. A large and an average sized specimen.

6. Surface of the smaller ×9.

Middle third of the Trenton shales at Minneapolis.

Figs. 7 to 9. BYTHOPORA ALCICORNIS, n. sp.. 26

7 and 8. Two specimens of the natural size.

9. Surface of the larger one ×9.

Upper third of the Trenton shales near Cannon Falls.

Figs. 10 to 16. HOMOTRYPELLA (?) SUBGRACILIS, n. sp.. 23

10 and 11. Two tangential sections ×18, showing slight differences.

12. Vertical section ×18.. The structure is almost entirely destroyed and only the direction of the tubes is to be made out with any certainty.

13 and 14. Two specimens, the second a little above the average in size.

15 and 16. Surface of the larger specimen ×9 and ×18.

Middle third of the Trenton shales, St. Paul.

Figs. 17 to 19. ERIDOTRYPA EXIGUA, n. sp.. 26

17. A group of fragments as they appear mounted on a slide.

18 and 19. Two of them ×9.

Upper part of the Galena shales near Cannon Falls.

Figs. 20, 21, 29 and 30. ERIDOTRYPA MUTABILIS, var. MINOR, n. var.. 26

20. Three fragments of the natural size.

21. Surface of one of them ×9.

29 and 30. Vertical and tangential sections ×18.

Galena shales near Cannon Falls.

Figs. 22 to 28, 31, 32. ERIDOTRYPA MUTABILIS, n. sp.. 26

22. A specimen of the average size.

23. Large example.

24. Surface of an old example presenting an unusual appearance, ×18.

25. Surface of the original of fig. 23, ×18. The figure includes one of the maculæ and exhibits the most common appearance of these.

26 and 27. Tangential section ×18 and a portion of same ×50; represents an average fully matured condition.

28. Vertical section of the same specimen ×18; shows a superficial layer of zoœcia growing in a direction opposite to the first set.

31 and 32. Vertical and tangential sections ×18, of an old specimen which has grown irregularly causing many interspaces and thus unusually numerous and large mesopores.

Galena shales, Goodhue county, Minn.

Figs 33 to 37. BATOSTOMA WINCHELLI Ulr.. 2

33. A specimen of the usual diameter.

34. Another, of large though not uncommon size.

35. An average example of the var. *nodosa*.

36. Surface of a fully matured example ×9.

37. Surface of the original of fig. 33 ×9 and ×18. (See also plate 27.)

Middle third of the Trenton shales, Minneapolis and St. Paul.

Figs. 38 to 40, BATOSTOMA MINNESOTENSE, n. sp.. 2

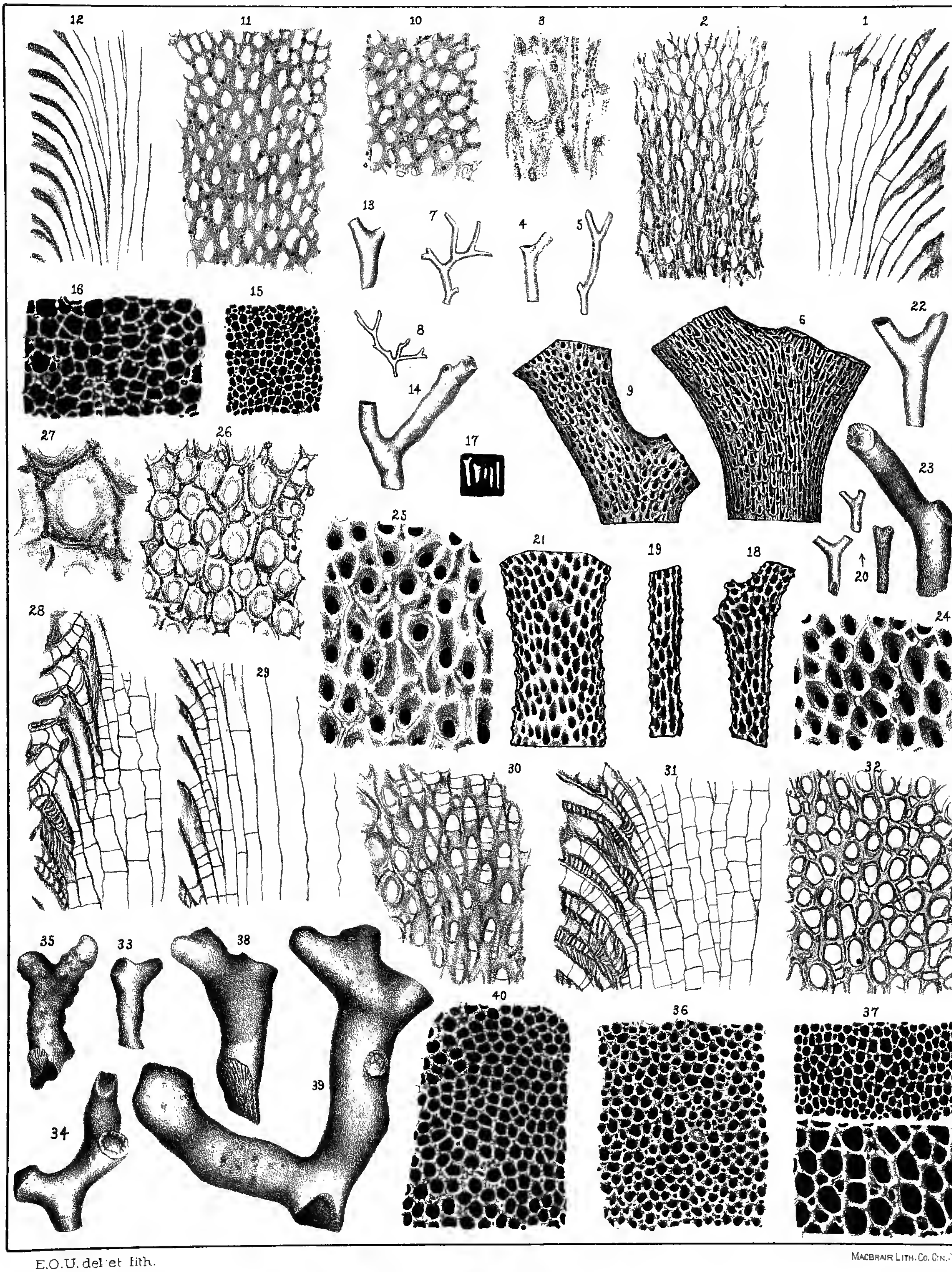
38 and 39. Two specimens, the first small, the other of the average size.

40. Surface of the larger specimen, which is in an excellent state of preservation, ×9, showing the granulose walls. (See also plate 27.)

Middle third of the Trenton shales, Minneapolis.

VOL. III

Plate 26.



E.O.U. del et lith.

MACBRAIR LITH. CO. CIN.

PLATE XXVII.

PAGE

Figs. 1 to 8. BATOSTOMA WINCHELLI Ulr. 29

1, 2 and 3. Vertical sections ×18, of a young, medium, and an old specimen.

4 and 5. Tangential section, ×18 and ×50, of the same specimen from which was prepared the vertical section shown in fig. 3.

6. Tangential section of a young specimen ×18.

7 and 8. Tangential section of the var *spinulosum* ×18 and ×50. (See also plate 26.)

Middle third of the Trenton shales, Minneapolis and St. Paul.

Figs. 9 to 15. BATOSTOMA MINNESOTENSE, n. sp. 29

9 and 10. Portions of a tangential section ×18 and ×50.

11 and 12. Peripheral and axial regions of a vertical section prepared from the same specimen as the preceding, ×18.

13. The peripheral part of a zoœcial tube with fewer diaphragms than usual, ×18. The true average for the species is intermediate between this and fig. 11.

14 and 15. Portions of two tangential sections, ×18 and ×50, in a different state of preservation than figs. 9 and 10. (See also plate 26.)

Middle third of the Trenton shales, St. Paul and Minneapolis.

Figs. 16 to 19. BATOSTOMA (?) DECIPIENS, n. sp. 29

16. Small portion of a vertical section ×18.

17 and 18. Tangential section ×18 and ×50. In some parts of this section certain small acanthopore-like dots are distinguishable usually about midway between the angles. They are dark and scarcely half the size of the smallest shown in fig. 10.

19. From the axial region of a transverse section ×18.

Lower half of the Trenton shales, Minneapolis.

Figs. 20 and 21. LEPTOTRYPA CLAVIFORMIS, n. sp. 31

20. Tangential section ×18. In this section the cells here drawn as open are filled with matrix, while those shaded are occupied by clear calcite. The smaller of the latter have the appearance of mesopores; on the other hand, since the preservation of the fossil is not favorable, it is possible that they represent acanthopores.

21. Vertical section of the upper extremity of same beyond the foreign body, ×18.

Middle third of the Trenton shales, St. Paul.

Figs. 22 and 23. LEPTOTRYPA INFORMIS, n. sp. 31

Tangential and vertical sections ×18.

Lower third of the Trenton shales, Minneapolis.

Figs. 24 and 25. LEPTOTRYPA ACERVULOSA, n. sp. 31

Tangential and vertical sections ×18.

Galena shales, Decorah, Iowa.

Figs. 26 and 27. MONOTRYPA (?CHÆTETES) CUMULATA, n. sp. 30

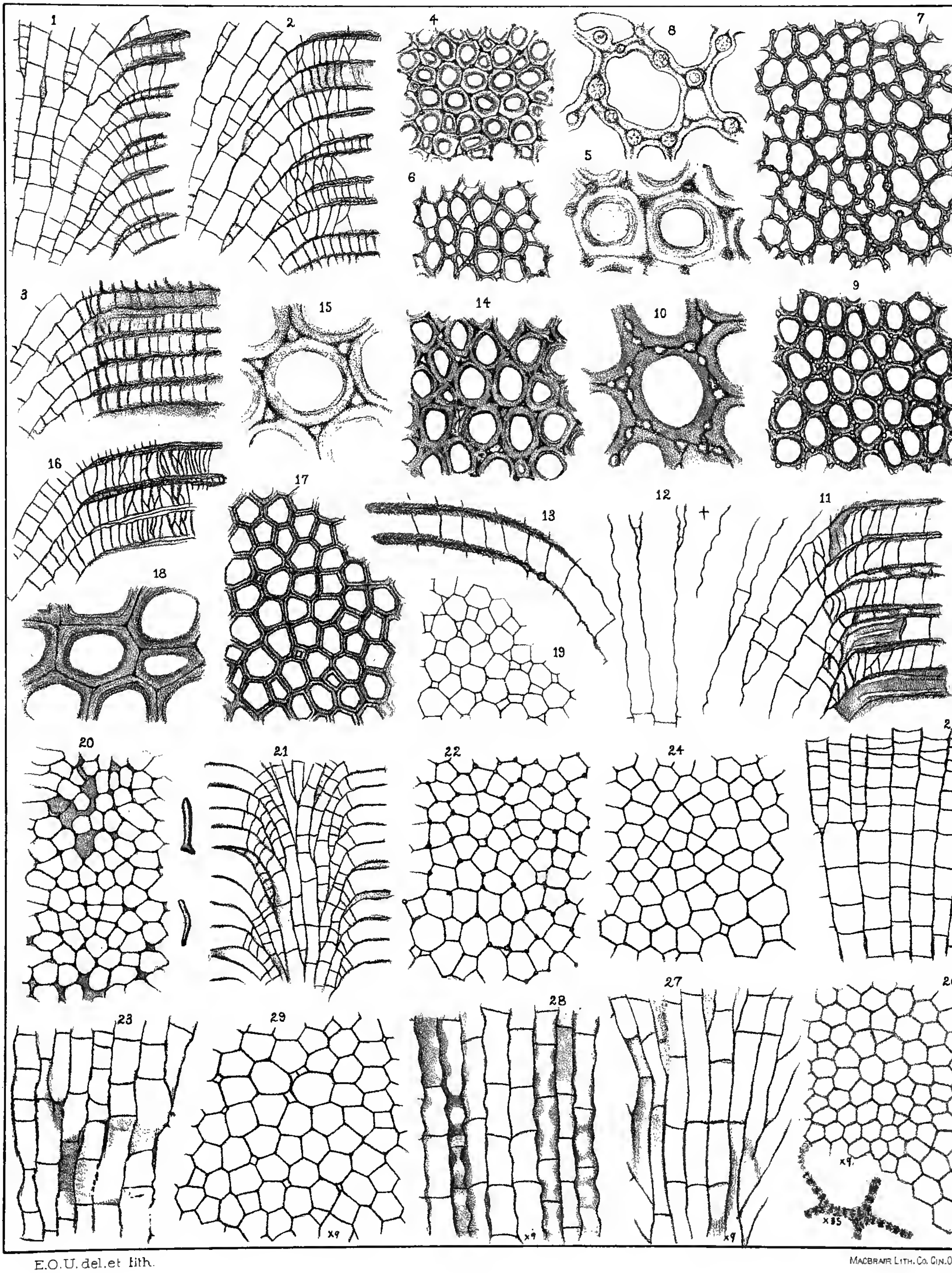
Tangential and vertical sections ×9. Beneath the first the structure of the wall is shown ×35.

Upper part of the Galena shales, Goodhue county, Minn.

Figs. 28 and 29. MONOTRYPA MAGNA, n. sp. 30

Vertical and tangential sections ×9.

"Lower Blue" limestone at Dixon, Ill.



E.O.U. del. et lith.

MACBRAIR LITH. CO. CIN. O.

PLATE XXVIII.

PAGE.

Figs. 1 and 2. SPATIOPORA LABECULOSA, n. sp. .... 32(
1. Surface, ×9, of a specimen with maculæ of the usual size. Others may have smaller maculæ and more numerous mesopores between the zoœcia.
2. Tangential section of same, ×18.
Middle third of the Trenton shales, Minneapolis, Minn.

Figs. 3 to 7. CERAMOPHYLLA FRONDOSA, n. gen. et sp. 331
3. Nearly complete frond of this species, nat. size.
4. Small portion of its surface, ×9, showing in the lower left hand corner the greater part of one of the maculæ.
5 and 6. Small parts of two tangential sections, ×18, the former illustrating the normal development, the latter an old and more irregular arrangement, and greater width of interspaces due to proximity to a macula.
7. Half of a vertical section, ×18; the tubes are divided somewhat obliquely and therefore do not show the full length of the prostrate portion.
Upper third of the Trenton shales, St. Paul, Minn.

Figs. 8 to 11. CERAMOPORELLA INCLUSA, n. sp. 329
8. Surface, ×9, of an example having the apertures filled with the clayey matrix.
9. Small portion of another example, ×18.
10. Larger part of the surface of the original of fig. 9, ×9.
11. Selected normally developed zoœcium, ×40.
Lower and middle thirds of the Trenton shales, Minneapolis, Minn.

Fig. 12. CERAMOPORELLA INTERPOROSA, n. sp. 330
Surface of an average specimen of this species ×18.
Galena Shales near Cannon Falls, Minn.

Fig. 13. CERAMOPORELLA DISTINCTA, Ulr. 328
Surface of a small specimen of this species from the lower third of the Trenton shales at Minneapolis; ×18.

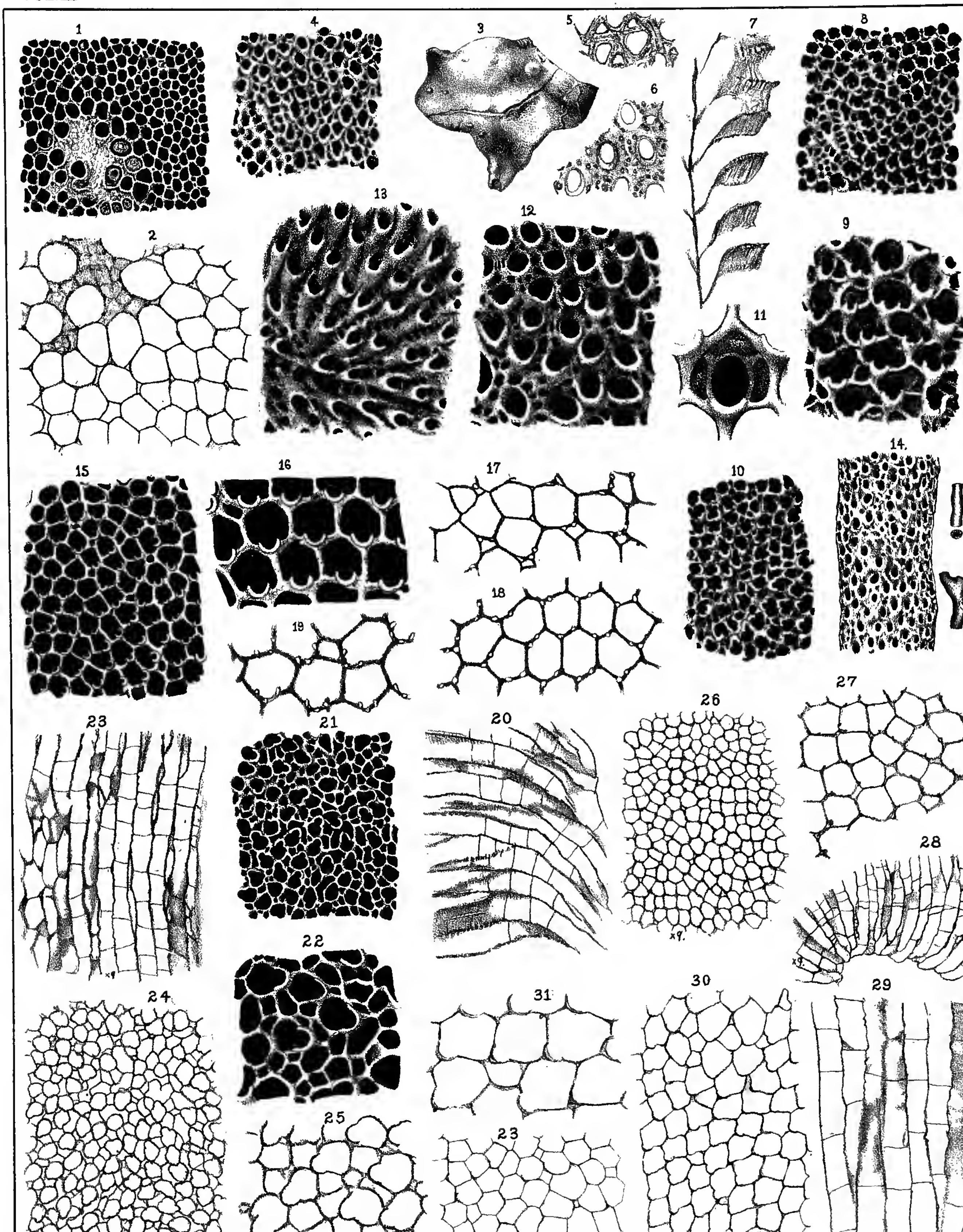
Fig. 14. DIAMESOPORA TRENTONENSIS, n. sp. 330
Two specimens of the natural size and the surface of the upper ×9. The form and arrangement of the zoœcia is a little irregular in this specimen. In others their shape approximates fig. 11.
Galena shales near Cannon Falls, Minn.

Figs. 15 to 20. ANOLOTICHIA IMPOLITA Ulr. 327
15 and 16. Surface ×9 and ×18.
17. From the axial region of a transverse section ×18.
18. Small portion of a tangential section ×18, of a specimen in which many of the lunaria have only two tubuli.
19. Portion of a typical section ×18.
20. Vertical section ×9.
Lower third of the Trenton shales, St. Paul and Minneapolis.

Figs. 21 to 25. BYTHOTRYPA LAXATA Ulr. 325
21 and 22. Surface of a well preserved specimen ×9 and ×18.
23 and 24. Vertical and tangential sections ×9.
25. Portion of the tangential section ×18.
Trenton shales, Minneapolis and St. Paul.

Figs. 26 to 28. CREPIPORA SUBÆQUATA, n. sp. 322
26 and 27. Tangential section ×9 and ×18.
28. Vertical section ×9, the entire thickness of the zoarium being shown in the right half of the figure.
Upper third of the Trenton shales, St. Paul.

Figs. 29 to 32. CREPIPORA PERAMPLA, n. sp. 323
29 and 30. Vertical and tangential sections ×9, the latter with the lunaria unusually distinct.
31. Portion of the tangential section ×18.
32. Another tangential section ×9, with the lunaria scarcely distinguishable.
Top of the Trenton limestone, Fillmore county, Minn.



E.O.U. del. et lith. MACBRAIR LITH. CO. CIN. O