A REVISION OF THE PALEOZOIC BRYOZOA

By E. O. ULRICH and R. S. BASSLER

Part I.—On Genera and Species of Ctenostomata

In 1897 Mr. Ulrich undertook the preparation of as complete a collection as possible of American fossil Bryozoa for the British Museum of Natural History. At the same time the late Professor Zittel of Munich wished a similar although somewhat smaller collection for his university. The junior author was at that time assisting Mr. Ulrich, so the two decided, while preparing these collections, to revise especially the generic and specific classification of the Paleozoic Bryozoa, as thoroughly as the material at hand would permit. With the exception of two short trips into the field, Mr. Ulrich spent two years in the preparation and study of thin sections and the separation of large collections embracing representative examples of the whole class. Mr. Bassler, besides aiding Mr. Ulrich in this work, also undertook the review of all the literature of Paleozoic Bryozoa and the compilation of a card catalogue of the American forms, using as a basis a list and bibliography prepared some years before by Mr. Ulrich. In 1900, Mr. Bassler, collaborating with Mr. John M. Nickles, who had prepared a similar card catalogue, published[1] much of the information concerning genera and all of the synonymy learned during the preparation of these collections and catalogues.

During the course of our studies, particularly of the *Trepostomata,* some four or five thousand thin sections were prepared. Of many species we made sometimes as many as a dozen sets of sections to determine the specific variation. Naturally the immense quantity of material studied afforded many new species, and these, besides aiding the strict characterization of the previously established generic groups, also served in distinguishing certain new genera that previously had been known only from species more or less imperfectly understood and therefore difficult to classify satisfactorily. At the same time a number of wholly new genera were determined, while other, perhaps equally distinct, groups require further material to prove the permanence of their peculiarities.

[1] *Bulletin 173, U. S. Geological Survey.*

As to the new species, they are to be numbered by the hundreds. This is indicated by the junior author's recent paper on *Homotrypa,*[1] in which the number of the Cincinnatian species of the genus previously described is more than trebled. While the specific representation of this genus of the *Trepostomata* is exceptional, it is still true that many of the other genera are very prolific in species and will continue to afford subjects for papers on new forms for years to come.

This and the following papers of this series are based almost entirely on the collection in the U. S. National Museum, which consists mainly of the recently-acquired Ulrich collection. This latter collection probably contains the largest series of Paleozoic bryozoa extant and is the result of thirty years of work on the part of Mr. Ulrich, with the assistance, at different times, of Mr. Charles Schuchert and the junior author. The Museum Paleozoic series has been augmented in the last few months by the collection of fossils made by Dr. Carl Rominger of the University of Michigan. In late years, large and excellent series of bryozoa have been collected for the Museum from horizons in which the Ulrich collection is lacking.

Dr. Frank Burns of the U. S. Geological Survey, during the course of his work in the Tertiary rocks, has collected many bryozoa in horizons where they were formerly supposed to be wanting. Dr. T. Wayland Vaughan has also discovered many bryozoa during the progress of his studies on the Tertiary corals of America. The study of these Tertiary collections is under way and it is hoped in the near future to publish papers on the subject.

All of the five orders of bryozoa comprising the subclass *Gymnolæmata* are represented in the Paleozoic rocks. Both species and specimens of the order *Ctenostomata* are usually rare. The *Trepostomata, Cryptostomata,* and *Cyclostomata* are quite abundant and commonly form a considerable part of the fauna. The *Chilostomata,* which includes so many Cenozoic and recent species, is doubtfully recognized in the Paleozoic, the single genus *Paleschara* probably belonging to this order.

We deem it only right to introduce here an explanation concerning the bryozoan chapter in the American edition of Zittel's *Textbook of Palæontology.* Several authors have alluded to the fact that the same genera occur both among the bryozoa and the corals. The explanation is very simple.

The coral chapter had been translated without revision and

[1] *Proc. U. S. National Museum,* XXVI, 1903, pp. 565–591.

printed before Mr. Ulrich had been asked to revise the chapter on the Bryozoa. When the manuscript for the latter was submitted, the author and the editor objected to the duplicate treatment of the Monticuliporoids, but withdrew their objection when Mr. Ulrich presented satisfactory evidence of the correctness of his classification.

In this connection it may be well to state also that, in the opinion of the writers, no valid objection to the reference of the Monticuliporoids and Fistuliporoids to the Bryozoa has ever been made. None of the recent critics on Lindstrom's, Rominger's, and Ulrich's reference of these fossil organisms with the Bryozoa is deemed of sufficient importance to demand serious attention. As to Waagen and Wentzel,[1] they appear to have known little of the American literature on the subject. Had they been better informed also concerning the wonderful abundance and variety of the Monticuliporoids and related organisms in American Paleozoic deposits, it is scarcely probable that they would have based a new classification on a very small collection of poor specimens.

Many facts bearing upon the relations of the Monticuliporoids to the later Bryozoa have come to light since the publication of the *American Paleozoic Bryozoa* by Ulrich in 1882. At some future time we shall marshal these facts in the hope that their publication may finally fix the position of these disputed forms.

In the present series of papers the efforts of the authors are directed primarily to the consideration of the generic groups, and in only one order, the *Ctenostomata,* a relatively small group considered in this paper, are all the known species considered.

Order CTENOSTOMATA Busk.

The earliest notice of the Paleozoic fossils, which seem now to be very generally accepted as imperfect remains of ancient representatives of Ctenostomatous Bryozoa, was by Nicholson and Etheridge, Jr., in 1877. In that year these acute observers published a paper in the *Annals and Magazine of Natural History* entitled "On Ascodictyon, a new Provisional and Anomalous Genus of Paleozoic Fossils." Three species of the new genus were described and well illustrated in this paper, namely, *Ascodictyon stellatum* and *A. fusiforme* from the Hamilton shales at Widder, Ontario, and *A. radians* from the Lower Carboniferous limestone of Scotland.

In discussing the systematic position and affinities of these species, the authors say that specimens were submitted to several authorities

[1] *Palæontologica Indica,* series XIII, 1886.

on the lower classes of invertebrates, among them Professor Huxley, who "suggested they might be Protozoans," H. B. Brady, who concluded that they cannot belong to the Foraminifera, and Mr. Hincks, who, with clear insight, "suggested that they were possibly allied to the recent *Ætea*." Nicholson and Etheridge were at first inclined to consider them as peculiar Foraminifera, but seem to have abandoned this view when Brady failed to see any such affinities in them. Other possible affinities suggested by them are with *Hydrozoa,* of which some of the stoloniferous Sertularians present certain points of resemblance. Their conclusion, after briefly weighing the possibilities is to "leave the question as to the systematic position of *Ascodictyon* . . . undecided."

In the same year Dollfus described *Terebripora capillaris,*[1] a new bryozoan from the Devonian of France and evidently a representative of the Ctenostomata.

In 1879[2] Ulrich proposed a new genus, *Rhopalonaria,* for another type of these obscure organisms. The genus was placed in the bryozoan family *Crisiidæ,* and the only species then known, well described and illustrated. Being at that time quite unacquainted with the Ctenostomatous Bryozoa, the true position of the fossil was not recognized.

In 1881[3] G. R. Vine published descriptions of two Silurian species of *Ascodictyon,* one of which was named *Ascodictyon stellatum* var. *siluricnse,* and the other doubtfully referred to *A. radians* Nicholson and Etheridge, Jr.

In a subsequent paper, published February, 1882,[4] Vine gives fuller details and figures of the Silurian species, and proposes two new names, *Ascodictyon radiciformis* for most of the forms previously referred by him to *A. radians,* and *Ascodictyon filiforme,* new species.

In 1884 this author published a third paper on *Ascodictyon*[5] in which, as he says in a subsequent publication, he "did his best to grapple with the systematic position of these fossils." Following a review of the literature, he "ventured on a new departure on my [his] own account." This is embodied in his remarks on p. 87

[1] *Bull. Soc. Lin. Normandie* (3), I, 1877.

[2] *Jour. Cin. Soc. Nat. Hist.,* II, p. 26.

[3] "Silurian Uniserial Stomatoporæ and Ascodictya," *Quart. Jour. Geol. Soc. London,* XXXVII, pp. 613–619.

[4] "Notes on the Polyzoa of the Wenlock Shales, etc.," *Quart. Jour. Geol. Soc. London,* XXXVIII, pp. 44–68.

[5] "Notes on Species of *Ascodictyon* and *Rhopalonaria* from the Wenlock Shales," *Ann. & Mag. Nat. Hist.,* ser. 5, XIV, pp. 77–89.

(op. cit.) : " There are not, so far as I am aware, any Cyclostomatous Polyzoa which may be considered as truly stoloniferous. Some of the Hydrozoa are, but I know of none whose stolons are adherent to stone or shell, such as are found in these ancient rocks; neither am I aware that the stoloniferous Ctenostomatous Polyzoa are adherent to stone or shell, like *Ascodictyon* or *Rhopalonaria*. Yet it seems to me that we have in *Ascodictyon filiforme*, at least, primitive representatives of stoloniferous *Vesicularüidæ*, such as *Vesicularia* or *Bowerbankia*, or possibly some member of the more humble race of the *Entoprocta*. Barrois has spoken of a pro-Bryozoan race, composed of free swimming organisms. May *Ascodictyon* be the attached or larval form of some of the as yet unknown pre-Upper Silurian types of organic life, polyzoan or otherwise?" The name *Rhopalonaria botellus* is suggested for a new type of these fossils.

In 1887, in a paper entitled " Notes on the Polyzoa of the Wenlock Shales, etc.,"[1] Vine gives further figures and descriptions of previously known Wenlock species of *Ascodictyon* and *Rhopalonaria*. In this paper the " Ascodictyæ " are referred to the *Stomatoporidæ*, which are Cyclostomata.

Terebripora capillaris Dollfus and *T. vetusta* new species are described by Oehlert in 1888 in an article entitled " Description de Quelques Espèces Dévoniennes du Département de la Mayenne."[2] Both species are apparently Ctenostomata of the genus *Rhopalonaria*, although we refer the latter doubtfully to this genus. Another foreign species which we doubtfully refer to *Rhopalonaria* is *Entobia antiqua* described by Portlock in 1843.[3]

In March, 1890,[4] Ulrich proposed a new genus, *Vinella*, " for an adnate form supposed to be a Ctenostomatous bryozoan, with relations to *Vesicularia* Thompson, and probably also to *Mimosella* Hincks." The fossil remains described and illustrated in this paper were interpreted as representing " the stoloniferous part of the bryozoan only," the zoœcia themselves being regarded as " having been deciduous and developed by budding from the creeping stolons at the parts now represented by small pores." Vine is credited as being the first to suggest the relation of *Rhopalonaria* and *Ascodictyon* to the Ctenostomatous Bryozoa.

In the same year appeared volume VIII of the reports of the Geological Survey of Illinois. The volume contains a revised

[1] *Proc. Yorkshire Geol. & Polytech. Soc.*, IX, p. 179.
[2] *Bull. Soc. d'Etud. Sci. d'Angers*, XVII, 1888, pp. 65–111.
[3] *Rep. Geol. County Londonderry*, 1843, p. 360.
[4] *Jour. Cin. Soc. Nat. Hist.*, XII, p. 173.

classification of the American Paleozoic Bryozoa by Ulrich, and the first definite assignment of *Ascodictyon* and *Rhopalonaria* to the *Ctenostomata.* The two genera are referred to a single family—the *Ascodictyonidæ.*

In 1891[1] Whiteaves described a species clearly referable to our new genus *Allonema* as *Stomatopora moniliformis* Whiteaves. It is from the Devonian, forty miles above the mouth of Hay river, Canada.

In 1892,[2] in a paper entitled "British Paleozoic Ctenostomatous Polyzoa," Vine again takes up the discussion of the *Ascodictyonidæ,* and returns to the opinions representing their relations suggested in his paper of 1884. Beginning with a good review of the subject, the paper continues with brief but pertinent remarks on five of the living families of the *Ctenostomata,* and concludes with descriptions of and critical remarks on the ten British species now referred more or less confidently to the *Ctenostomata.* Of these, *Ascodictyon youngi* Vine, from the Lower Carboniferous shales of Scotland, is described for the first time.

In January, 1893, when advance copies of the work were distributed, and in 1895, when the volume of which it is a part was issued,[3] Ulrich republished the original diagnosis and figures of *Vinella.* Accompanying this are figures and descriptions of two other forms of this genus, *Vinella radialis* Ulrich, and *Vinella radiciformis* var. *conferta* Ulrich, and also of *Ascodictyon stellatum* Nicholson and Etheridge, Jr., and *Rhopalonaria venosa* Ulrich. The propriety of including the three genera *Ascodictyon, Vinella,* and *Rhopalonaria* in one family, the *Ascodictyonidæ,* is doubted. The author states further that he is "satisfied that *Rhopalonaria* at least, which is evidently related to the recent *Arachnidium* Hincks, belongs to a distinct family." This family, *Rhopalonariidæ,* was recognized by Nickles and Bassler in the classification published by them in 1900.[4]

In 1897[5] Simpson published copies of descriptions and figures of some of the Paleozoic Ctenostomata described by previous writers. No new matter is added concerning the order of Bryozoa under consideration. Miller's brief description of *Ascodictyon* and

[1] *Contr. to Canadian Paleontology,* vol. I, p. 212.

[2] *Proc. Yorkshire Geol. & Polytech. Soc.,* n. s., XII, pt. I, pp. 74–93.

[3] *Geol. of Minnesota,* Final Rept., III, pt. I, chap. iv, "On Lower Silurian Bryozoa of Minnesota."

[4] "Synopsis of the American Fossil Bryozoa," *Bull. 173, U. S. Geol. Surv.,* p. 19.

[5] *Fourteenth Ann. Rep. State Geol. New York.*

register of American species in his *American Geology and Paleontology,* 1898, and similar treatment of *Vinella* in the Supplement published three years later, likewise add nothing new to the subject.

The above references, it is believed, constitute a complete historical sketch of the subject. As we describe, or at least make critical remarks about every known species, and, with few exceptions, give one or more figures of each, this work might perhaps justly claim the rank of a monograph. However, we are far from claiming any such dignity for our effort, its aim being no higher than the production of something that might prove a useful basis for further investigations.

It should be stated in this connection that we know little about these fossils, and while their classification with the Ctenostomata is perhaps a little better than a mere working theory, it rests mostly on highly suggestive resemblances between the incomplete fossil organisms and the supposed corresponding parts of living forms, and upon conjectures as to the unknown parts. Still, whatever position may ultimately be assigned to them, it seems certain that their reference to the Ctenostomatous Bryozoa is at present opposed by fewer objections and at the same time supported by more and stronger agreements than appear when they are compared with any other class of organisms.

The only objection that might be considered valid is the difference between the chemical constituents of the zoarium of the recent Ctenostomata and their supposed Paleozoic ancestors. In the former the zoarium is either horny or membranaceous, and in many cases perhaps quite incapable of preservation in the fossil state. In the ancient types, on the contrary, the zoarium, though not by any means so calcareous as in other types of Bryozoa, nevertheless contained enough hard and resistant matter to render them capable of fossilization. In some the preservation is generally good, in others rarely satisfactory, while all exhibit unmistakable differences in the composition of their zoaria when compared with associated similarly adnate but purely calcareous zoaria of Cyclostomata like *Stomatopora.* Unfortunately we are unable to say what these differences consist of, but we have no reason to doubt that they are of kinds comparable with those existing between recent Cyclostomata and Ctenostomata.

Of the various forms referred to here as Paleozoic Ctenstomata, none, with the possible exception of *Rhopalonaria,* is known by its zoœcia. Assuming provisionally that the fusiform swellings of *Rhopalonaria* are really the zoœcia, we are at once confronted by

the difficulty of explaining why they seem to be without clearly defined orifices. A small spot may often be detected that looks different from the rest of the swelling, and that most probably represents some kind of orifice, but none of the numerous specimens before us is in a state of preservation good enough to establish its nature beyond doubt.

Considering the non-calcareous character of the zoœcia of recent Ctenostomata in connection with the fact that the preservation of the zoarium of *Rhopalonaria* shows that it also was not composed of material favorable to ordinary fossilization, the lack of definiteness about the zoœcial orifice of the fossils may justly be regarded as confirming an alliance with Ctenostomata rather than as purely negative evidence. As a rule, nothing remains of the *Rhopalonaria* but the peculiar and characteristically arranged, excavated counterfeits of the parasitic zoœcia and stolons in the test of the host. Occasionally we meet with the fossilized zoarium itself. This is nearly always dark in color and more or less pyritized. Very rarely it is preserved as a siliceous pseudomorph, the silicification of the zoarium having taken place prior to the solution and removal of the calcareous shell in which it was partly imbedded.

Comparing what we know of *Rhopalonaria* with recent Ctenostomata, we find a striking agreement in the form, connections, and arrangement of the zoœcia of *Arachnidium,* of which we present in plates LXV and LXVI somewhat sketchy copies of figures of two species by Hincks. The zoœcial orifice in *Arachnidium,* it will be observed, is small, and (a fact not brought out in our figures), is covered by a pyramid of stout setæ forming a closure quite different from those occurring in either the Chilostomata or Cyclostomata. With these minute plates in place, it may be quite readily conceived that even under favorable conditions of fossilization, the position and character of the zoœcial orifice of a fossil *Arachnidium* would be obscure. The zoœcial orifice in the recent species, it will be further observed, is near the distal extremity of the zoœcium. In *Rhopalonaria* this is not the case, since the possible zoœcial orifice in the fusiform swelling is generally much nearer the center.

Viewing *Rhopalonaria* as the creeping base of some otherwise unknown bryozoan, the subcentral position of the orifice-like spot becomes significant, for we can now see that it corresponds in all essential respects with the creeping base of a recent *Ætea.* Plate LXV, 1, 2, illustrates portions of the base of two species of that genus, *A. anguinea* and *A. truncata,* the former showing also some of the erect zoœcia. At the attached basal end of the zoœcia there is a

minute perforation in the corresponding subfusiform swelling of the adnate base. The position of this perforation is generally more nearly central than terminal, and thus corresponds with the facts observed on *Rhopalonaria.* The only feature in which the known parts fail to correspond is the greater regularity of the development and arrangement of the fusiform swelling of the base in the *Rhopalonaria.* This surely cannot be of sufficient consequence to deter us from classifying *Rhopalonaria* as an ancient representation of the *Æteidæ* and more typical Ctenostomata.[1]

The method of growth prevailing in *Rhopalonaria* is exactly duplicated in D'Orbigny's genus *Terebripora,*[2] the known species of which are described and in part figured by Fischer.[3] There is, however, a notable difference between the latter genus which contains recent species chiefly and the Paleozoic *Rhopalonaria,* namely, that in *Terebripora* the cell between the connecting stolons is the zoœcium itself with a subterminal orifice bearing a sinus on its lower margin. *Terebripora* agrees in all essential respects with such Chilostomata as *Hippothoa,* and there can be little doubt that it also is a member of this order. It would be very desirable in the present state of our knowledge that some one should undertake the study of these recent forms in the hope of throwing some light on their possible Paleozoic representatives.

The delicate thread-like creeping stolons of *Vinella* and *Heteronema,* new genus, with their median rows of small pores, are, we believe, strictly comparable with the branching stems which support the deciduous zoœcia of *Vesicularia,* a typical Ctenostomatous bryozoan. In plate LXV, 4, 5, are reproduced two of Hincks' illustrations, somewhat reduced, of *V. spinosa* Linnæus. Comparing these with *Vinella,* we observe no differences of greater importance than such as might be expected between members of the same order of organisms. Indeed, they are often greater, as in the case of *Arachnidium* and *Vesicularia,* a comparison of whose zoaria constantly brings out more distinctions than can be made out between those of *Vesicularia* and *Vinella.* The point that is deemed the most significant in the comparison is the row of pores on the branching stem in the one case and the creeping stolons in the other, which in the case of *Vesicularia* do, and in *Vinella* are believed to, mark the

[1] Hincks (*British Marine Polyzoa*) arranges *Ætea* with the *Chilostomata,* but admits the Ctenostomatous affinities of the genus. In our opinion the latter predominate decidedly over the former.

[2] *Voyage dans l'Amérique Merid.,* t. VI, 1839, p. 23, pl. X.

[3] *Nouv. Arch. Mus. Hist. Nat.,* II, 1866, pp. 293–313, pl. XI.

attachment of the zoœcia. The fact that the recent forms are erect and the fossil ones parasitic is not of much consequence, since the same difference occurs over and over again between many otherwise closely related genera of Bryozoa.

Vine (op. cit., 1892) has already pointed out most of the similarities of structure existing between *Ascodictyon* and our proposed *Allonema,* on the one hand, and the recent genus *Valkeria* on the other. Our reproduction of one of Hincks' figures of *Valkeria uva* shows the two features principally relied on in comparing *Valkeria* with *Allonema,* namely, the jointed character of the stem and the pores on the segments marking the points where the deciduous zoœcia were attached. The form of the zoœcial buds and their frequent arrangement in verticils, as in the upper branch on the left side of the figure, are, as pointed out by Vine, extremely suggestive of *Ascodictyon.* It is to be contended, however, that if the vesicles of *Ascodictyon* are zoœcia, then they must, in all cases observed by us, be only either young or abortive ones. We are inclined to doubt this and to regard them rather as a special kind of zooid, in which case the true zoœcia still remain to be discovered. The great variation in size of the vesicles shown by our figures of the known species on plate LXVIII, is regarded as supporting the latter view, such a variation in the zoœcia appearing quite unlikely to us.

The various alliances indicated in the foregoing comparisons make it clear that, even in a confessedly provisional classification, a single family should no longer be made to include all the various types now classed as Paleozoic Ctenostomata. Even with the recognition of a second family, the *Rhopalonariidæ,* the necessities of the case are not satisfied. Indeed, the need of a third family is only emphasized by the adoption of the second. It might be suggested that if *Vinella* and the related genus *Heteronema* are to be eliminated from the *Ascodictyonidæ,* that they be referred to the recent family *Vesiculariidæ* with which we have compared them. That step, however, seems to us much more objectionable than the erection of a new family for their special benefit, since it would indicate a degree of relationship that is scarcely warranted by our present knowledge, and certainly a greater one than we are willing to admit at present.

Under the circumstances the following provisional arrangement of the genera and species seems to us the least objectionable. Time and further research alone can determine whether or not it is based on facts insuring its permanence:

Order *CTENOSTOMATA* Busk.

Family RHOPALONARIIDÆ Nickles and Bassler.

Genus RHOPALONARIA Ulrich.

R. venosa Ulrich. Ordovician—Richmond formation.
R. attenuata new species. Silurian—Clinton limestone and Rochester shales.
R. ? antiqua (Portlock). Silurian of Ireland.
R. robusta new species. Devonian—Camden chert.
R. tenuis new species. Devonian—Hamilton formation.
R. medialis new species. Devonian—Hamilton formation.
R. capillaris (Dollfus). Devonian of France.
R. ? vetusta (Oehlert). Devonian of France.
R. keokukensis new species. Mississippian—Keokuk formation.

Family VINELLIDÆ new family.

Genus VINELLA Ulrich.

V. repens Ulrich. Ordovician—Black River formation.
V. radialis Ulrich. Ordovician—Lorraine formation.
V. radiciformis (Vine). Silurian—Wenlock and Rochester shales.
V. radiciformis conferta Ulrich. Silurian—Waldron shales.
V. ? multiradiata new species. Silurian—Rochester shales.
V. ? radians (Nich. & Ethr., Jr.). Carboniferous of Scotland.

Genus HETERONEMA new genus.

H. capillare new species. Silurian of Gotland.
H. ? contextum new species. Ordovician—Lorraine formation.
H. carbonarium new species. Pennsylvanian.

Genus ALLONEMA new genus.

A. botelloides new species. Silurian of Gotland.
A. botellus (Vine). Silurian of Gotland and England.
A. waldronense new species. Silurian—Waldron shale.
A. subfusiforme new species. Silurian of Gotland.
A. fusiforme (Nich. & Ethr., Jr.). Devonian—Hamilton formation.
A. moniliforme (Whiteaves). Upper Devonian.
A. moniliforme-aggregatum new variety. Devonian-Hamilton formation.
A. ? minimum new species. Pennsylvanian.

Family ASCODICTYONIDÆ Ulrich (Restricted).

Genus ASCODICTYON Nicholson and Etheridge, Jr.

A. siluriense Vine. Silurian—Rochester and Wenlock shales.
A. filiforme Vine. Silurian—Wenlock shales.

A. stellatum Nich. & Ethr., Jr. Devonian—Hamilton formation.
A. floreale new species. Devonian—Hamilton formation.
A. parvulum new species. Mississippian—Chester group.
A. sparsum new species. Mississippian—Chester group.
A. youngi Vine. Carboniferous of Scotland.

Position Doubtful.

Genus PTYCHOCLADIA new genus.

P. agellus new species. Pennsylvanian.

Family RHOPALONARIIDÆ Nickles and Bassler.

Genus RHOPALONARIA Ulrich.

1879. *Ropalonaria* ULRICH, Jour. Cin. Soc. Nat. Hist., II, p. 26.
1882. *Ropalonaria* ULRICH, Ibid., V, p. 149.
1884. *Rhopalonaria* VINE (partim), Ann. Mag. Nat. Hist., ser. 5, XIV, p. 84, fig. iv.
1887. *Rhopalonaria* VINE (partim), Proc. Yorkshire Geol. and Polyt. Soc., IX, p. 185.
1889. *Rhopalonaria* MILLER, North Amer. Geol. and Pal., p. 321.
1890. *Rhopalonaria* ULRICH, Geol. Surv. Illinois, VIII, p. 367.
1892. *Rhopalonaria* VINE, Proc. Yorkshire Geol. and Polyt. Soc., XII, p. 91.
1897. *Rhopalonaria* SIMPSON, Fourteenth Ann. Rep. State Geol. New York for 1894, p. 603.
1900. *Rhopalonaria* NICKLES and BASSLER, Bull. U. S. Geol. Surv., No. 173, p. 19.

Zoarium adnate, excavating the surface of the host so as to become usually about half embedded in it; consisting, so far as known, of fusiform internodes or cells connected by extremely delicate tubular stolons, the whole arranged in a primate manner. Zoœcia unknown, probably deciduous and developed by budding from a subcentrally situated pore in the internodes.

Genotype *R. venosa* Ulrich.

The principal generic and family character is the faculty of excavating the body grown upon by the creeping base, the zoarium. As a rule nothing remains except these clay filled or empty excavations, but as they are sharp and true impressions of the stolons, and the species are distinguished chiefly by variations in their dimensions, the impressions serve quite as well in discriminating the species as the more complete specimens.

In the latter the stolons are in semi-relief and black in color, with the pores and possibly other surface features generally more or less obscured, or quite obliterated, by pyritization.

The known species are all Paleozoic, the oldest occurring in the

Richmond or closing age of the Ordovician, the last in the Keokuk formation of the Mississippian series.

In 1884, and again in 1887 (op. cit.), Vine described a *Rhopalonaria botellus* and thereby confused this and the other very different species upon which we found the new generic group *Allonema*. In 1886[1] Ulrich added to the confusion by describing a variety of *Stomatopora delicatula* James as *Rhopalonaria pertenuis,* an error that was corrected in his later work on Minnesota Bryozoa.

RHOPALONARIA VENOSA Ulrich

(PLATE LXVI, 2, 3)

1879. *Rhopalonaria venosa* ULRICH, Jour. Cin. Soc. Nat. Hist., II, p. 26, pl. vii, 24, 24*a*.

1889. *Rhopalonaria venosa* MILLER, North Amer. Geol. and Pal., p. 321, fig. 511.

1893. *Rhopalonaria venosa* ULRICH, Geol. Minnesota, III, p. 114, fig. 8*c*.

1897. *Rhopalonaria venosa* SIMPSON, Fourteenth Ann. Rep. State Geol. New York for 1894, p. 603, fig. 221.

Zoarium growing on various bodies—corals, brachiopods, and shells of pelecypods. Cells distinctly swollen, fusiform, connected by very slender stolons of an average length equaling that of the cells, all arranged somewhat irregularly in a pinnate manner, an average of 5 or 6 cells in the midrib in 3 mm. and the same number in the lateral branches in 4 mm. Occasionally an arrangement simulating the web of a spider may be observed in large colonies. Fusiform cells averaging 0.1 mm. or less in diameter and about 0.3 mm. in length; many with a minute, elevated, eccentrically situated pore-like spot.

On account of the extreme simplicity of these fossils, we find it difficult to draw up satisfactory descriptions. The size, form, and arrangement of the cells and the relative average length of the connecting tubes are the points relied on in distinguishing the species. In recognizing these the illustrations will doubtless prove of greater service than descriptions, and the latter, therefore, will consist principally of comparative remarks.

Occurrence.—Richmond group, numerous localities in Ohio and Indiana. The types are from Waynesville and Clarksville, Ohio.

Cat. Nos. 43,111–43,115, U. S. N. M.

RHOPALONARIA ATTENUATA new species

(PLATE LXVI, 4, 5)

In this species the length and arrangement of the internodes and stolons is practically the same as in *R. venosa,* but its colonies are

[1] *Fourteenth Ann. Rep. Geol. Nat. Hist. Surv. Minn.,* p. 59.

readily distinguished by the extreme tenuity of its parts, and the comparative rigidity of their arrangement. The fusiform swellings are not only narrower but also shorter and correspondingly farther apart. *R. tenuis* new species of the Hamilton formation is a similarly attenuate species but has longer cells.

Only the excavations or molds of this species have been seen.

Occurrence.—Rochester shale, Lockport, N. Y.; Clinton limestone, near Mifflintown, Juniata county, Pa.

Cat. Nos. 43,116, 43,117, U. S. N. M.

RHOPALONARIA ? ANTIQUA (Portlock)

(Not figured)

1843. *Entobia antiqua* PORTLOCK, Rep. on Geol. County Londonderry, p. 360, pl. XXI, fig. 5*a*.

1854. *Cliona antiqua* MORRIS, Cat. Brit. Foss., p. 27.

1866. *Terebripora ? Portlocki* FISHER, Nouv. Arch. de Mus. d'Hist. Nat. Paris, t. 12, p. 307.

A reinvestigation of the type or typical specimens is necessary before the generic position of this species can be determined without question, and until this is done we prefer to refer to the species as above. Although agreeing in most respects with *Rhopalonaria,* Portlock's figure of *Entobia antiqua* presents a few characters that cause us to make the reference doubtfully.

Occurrence.—Silurian of Ireland.

RHOPALONARIA ROBUSTA new species

(PLATE LXVI, 6)

Of this species we have seen only a single colony, but its fusiform cells are so much larger and the connecting stolons so much shorter than any of the other forms known that we cannot hesitate in pronouncing it distinct. The fusiform cells average about 0.12 mm. in diameter and nearly 1.0 mm. in length. As usual the average length of those in the midrib is appreciably greater than of those forming the lateral branches and their connections.

The specimen occurs in a block of chert which contains numerous natural molds of brachiopods. Originally it grew upon the inner side of one of their valves. This was subsequently entirely removed by solution, nothing remaining now in the mold but a siliceous pseudomorph of the *Rhopalonaria. R. capillaris* (Dollfus) from the Devonian of France is a closely allied species, but differs in having elongate elliptical cells connected by proportionally much longer and sharply defined stolons.

Occurrence.—Camden chert, Camden, Tennessee.

Cat. No. 35,089, U. S. N. M.

RHOPALONARIA TENUIS new species

(PLATE LXVI, 7, 8, 9)

Fusiform cells attenuate, averaging about 3 in 2.0 mm., occasionally only 4 in 3.0 mm.; greatest diameter of same about 0.5 mm. On the best specimen many of the cells preserve remains of the pores. Of these there is usually only one situated near the center of the cell, but in others there appear to be two pores. The connecting stolons rarely equal the fusiform swellings in length, the average, however, is considerably less.

The general aspect of the colony is greatly like that of *R. venosa,* but when critically compared the fusiform cells of the Devonian species prove to be both narrower and longer, and the connecting stolons generally shorter than the Ordovician type of the genus. In the Silurian species, *R. attenuata,* the fusiform swellings, though about equally narrow, are considerably shorter and enlarge more abruptly, while the connecting stolons are much longer.

The original of figure 9, plate LXVI, is doubtfully referred to this species. It consists of the excavations only, but these are so closely arranged that it is difficult to make out the series. Evidently several branches cross each other.

Occurrence.—The figured type is from the lower shales of the Hamilton formation at Thedford, Ontario. The species also occurs in the same formation at Alpena, Michigan, and Eighteen-Mile creek, New York.

Cat. Nos. 43,118, 43,119, and 43,121, U. S. N. M.

RHOPALONARIA MEDIALIS new species

(PLATE LXVI, 10)

Compared with other species the colonies of this form appear less compact and the arrangement of the cells more straggling. In the matter of size, the fusiform cells are more robust than in any of the other forms except *R. robusta,* the position of the species in this respect being almost exactly intermediate between *R. robusta* and *R. venosa.* About 4 of the cells in the middle series occur in 3.5 mm., while of those in the lateral branches the average number in an equal space is about 5. The connecting stolons are rather short, the average length not exceeding two-thirds that of the fusiform swellings.

Compared more particularly with the associated *R. tenuis,* it is distinguished at once by its more robust aspect and looser habit of growth.

Occurrence.—Lower shales of Hamilton formation at Thedford, Ontario.

Cat. No. 43,120, U. S. N. M.

RHOPALONARIA CAPILLARIS (Dollfus)

(Text figure 32)

Terebripora capillaris Dollfus, Bull. Soc. Linn. Normand. (3), I, 1877, p. 96, pl. I, figs. 2–4.

Terebripora capillaris Oehlert, Bull. Soc. d'Etud. Sci. d'Angers, XVII, 1888, p. 107.

Judging from Dollfus' figure, a reduced copy of which is here reproduced as text figure 32, this species appears to be closely allied to our *Rhopalonaria robusta,* although in some respects it approaches the genotype *R. venosa.* Although agreeing with the former in size, *R. capillaris* is distinguished by the elongate elliptical rather than fusiform shape of its cells and by its proportionately much longer and more sharply defined connecting stolons. The greater regularity and more robust growth of *R. capillaris* will distinguish it from *R. venosa.*

Fig. 32.—*Rhopalonaria capillaris* (Dollfus). × 9. Devonian of France.

Occurrence.—Devonian of France.

RHOPALONARIA? VETUSTA (Oehlert)

(Text figure 33)

Terebripora vetusta Oehlert, Bull. Soc. d'Etud. Sci. d'Angers, XVII, 1888, p. 108, pl. X, fig. 3.

Fig. 33.—*Rhopalonaria? vetusta* (Oehlert). × 9. Devonian of France.

Oehlert's illustration, of which text figure 33 is a reduced tracing, shows that this species does not conform strictly with *Rhopalonaria,* but that it is doubtless more closely related to this genus than to *Terebripora.*. The differences from the typical forms of *Rhopalonaria* are particularly the arrangement of the cells and stolons and the short subangular form of the impressions of the cells. It is possible that the portion of the zoarium figured by Oehlert may represent a part where buds from neighboring branches, by growth over each other, obscured the regular development. The

other species of *Rhopalonaria* are so different that comparison is unnecessary.

Occurrence.—Devonian of France.

RHOPALONARIA KEOKUKENSIS new species

(PLATE LXVI, 11)

In this species the branches divide and throw off equal branches at such frequent intervals that the pinnate arrangement of the cells is generally very much obscured. The fusiform cells are narrow and vary from 0.5 mm. to 0.6 mm. from center to center. They are longer than the connecting threads, the relations of the former to the latter being, respectively, about as 3 is to 2.

The proportions of the cells and stolons are very similar to those found in the Devonian *R. tenuis,* still there is a slight difference in the length of their internodes, while the pinnate arrangement of the latter is much less obvious in *R. keokukensis* than in *R. tenuis.* If both forms had occurred in the same geological formation, we might have considered them as varieties of one species, but since the differences noted are supported by great disparity in their ages, we cannot hesitate to distinguish them specifically. In cases like this we should also remember that the unknown parts of the organisms most probably were more sharply differentiated.

Occurrence.—Keokuk formation, Keokuk, Iowa.

Cat. No. 43,122, U. S. N. M.

Family VINELLIDÆ new family

In its simplest form, *Heteronema,* the creeping base of this family, consists of usually simple, though locally jointed, delicate, partially ramifying, orderless tubular threads. Where pores have been observed on these they always occurred in a single row. As a variation from this simplest type, we have *Vinella,* consisting of similar delicate threads but having them arranged in such manner that they proceed from more or less definite centers. In the third generic type, *Allonema,* the orderless arrangement of the threads observed in *Heteronema* is maintained, but its segmentation has assumed the importance of a constant character and instead of a single row of pores the internodes are covered with them. Perhaps, on account of the last feature, *Allonema* should have been arranged with *Ascodictyon* rather than *Vinella,* the punctate internodes being comparable with the similarly punctate vesicles of that genus. Possibly they are homologous, even, but in either case *Ascodictyon* possesses charac-

ters not found in the *Vinellidæ,* namely, two permanently and widely distinct structures—bulbous vesicles and extremely delicate connecting stolons. If the simple or segmented threads of the *Vinellidæ* are, as we believe, homologous with the vesicles of *Ascodictyon,* then the connecting stolons of the latter are wanting in this family. If, on the other hand, they represent the stolons, then there is nothing to compare with the vesicles.

Genus VINELLA Ulrich

1890. *Vinella* ULRICH, Jour. Cincinnati Soc. Nat. Hist., XII, p. 173.
1892. *Vinella* MILLER, North Amer. Geol. and Pal., First app., p. 685.
1892. *Vinella* VINE, Proc. Yorkshire Geol. & Polyt. Soc., XII, p. 84.
1893. *Vinella* ULRICH, Geol. Minnesota, III, p. 112.
1897. *Vinella* SIMPSON, Fourteenth Ann. Rep. State Geol. N. Y. for 1894, p. 604.
1900. *Vinella* NICKLES AND BASSLER, Bull. U. S. Geol. Surv., No. 173, p. 19.

Zoarium parasitic, consisting of very slender, tubular threads or stolons, arranged more or less distinctly in a radial manner. Surface of threads with a single row of small pores. These may be wanting locally, and vary considerably in the degree of their separation. Zoœcia unknown, probably deciduous.

Genotype.—V. repens Ulrich.

Of the following species only the genotype and *V. radiciformis* (Vine), together with its variety *conferta* Ulrich, are confidently referred to this genus. As to Nicholson and Etheridge's *Ascodictyon radians,* from the Carboniferous of Scotland, we are satisfied that it is not an *Ascodictyon* and equally confident that it is nearer to *Vinella* than it is to the typical forms of the genus in which it has hitherto been placed. Still, the considerable thickness of the inner parts of the radii and the root-like taper of their distal halves give the organism an aspect that certainly *looks* different from the more typical species of *Vinella.* Excepting, of known characters, that its radii maintain approximately the same diameter (*i. e.,* they do not taper), our new species *V.? multiradiata,* may be said to parallel the Carboniferous species. Both have a central cup, with a raised border that possibly represents the broken base of an erect zoœcium like those in the recent *Cylindroecium dilatatum* Hincks (see plate LXV, 3). The only known example of *V.? multiradiata,* unfortunately, has suffered enough from weathering to obliterate whatever minute structure it may have possessed, so we are unable to decide as to its true affinities. The species *radians,* however, is said to occur abundantly and, apparently in a state of preservation sufficiently

favorable to justify the hope that an examination of good specimens may throw further light upon its systematic position. In the meantime we propose to arrange the species as a doubtful *Vinella*.

VINELLA REPENS Ulrich

(PLATE LXVIII, 1–3)

1890. *Vinella repens* ULRICH, Jour. Cincinnati Soc. Nat. Hist., XII, p 174, fig. 1.

1893. *Vinella repens* ULRICH, Geol. Minnesota, III, p. 114, pl. I, figs. 1–5.

1897. *Vinella repens* SIMPSON, Fourteenth Ann. Rep. State Geol. New York for 1894, p. 604, fig. 222.

Not *Vinella repens* VINE, 1892, Proc. Yorkshire Geol. & Polyt. Soc., XII, p. 84, pl. iii, figs. 1–4. (= Probably *Heteronema*, sp. undet.)

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 upper surface of the threads; about 11 in 2.5 mm. Zoœcia unknown, probably deciduous."

We have no amendments to make to the original description of this species reprinted above. A few additional specimens have been found, but these add nothing to the features observed in the type lot of specimens.

In Vine's last paper on Paleozoic Ctenostomata (loc. cit.), he identifies this species among his Wenlock fossils, and distinguishes another form as a variety *contorta*. Neither the descriptions nor the figures given by Vine are satisfactory, but using them in connection with private information we have arrived at the conclusion that they are quite distinct from this species and probably not even congeneric. Both are believed to belong to *Heteronema* and possibly to the species which we describe as new under the name *H. capillare*.

Occurrence.—Phylloporina beds of the Black River formation, St. Paul, Minnesota.

Cat. No. 43,148, U. S. N. M.

VINELLA RADIALIS Ulrich

(PLATE LXVIII, 4)

1893. *Vinella radialis* ULRICH, Geol. Minnesota, III, p. 113, fig. 8*b*.

In this delicate species the radial disposition of the threads is well developed. In the original and only known specimen there are four complete centers and rays and parts of two others. The rays are rigid, 4 to 7 mm. long and vary in number in each set from seven to

seventeen. The preservation of the specimen is not favorable enough to show either the pores on the threads or character of the centers.

Occurrence.—Corryville beds of the Lorraine formation, Cincinnati, Ohio.

Cat. No. 43,149, U. S. N. M.

VINELLA RADICIFORMIS (Vine)

(PLATE LXVIII, 7)

1881. *Ascodictyon radians* VINE (part), Quart. Jour. Geol. Soc. London (provisional placement), XXXVII, p. 619.

1882. *Ascodictyon radiciforme* VINE, Ibid., XXXVIII, p. 53, figs. 1, 3.

1884. *Ascodictyon radiciforme* VINE, Ann. & Mag. Nat. Hist., ser. 5, XIV, p. 83, figs. 1–5.

1887. *Ascodictyon radiciforme* VINE, Proc. Yorkshire Geol. & Polyt. Soc., IX, pp. 183–4, pl. 12, fig. 5.

1892. *Ascodictyon radiciforme* VINE, Ibid., XII, p. 87.

1893. *Vinella radiciformis* ULRICH, Pal. Minnesota, III, pt. 1, p. 113.

This species is distinguished from *V. repens* by the much greater tenuity of the zoarial threads, their average thickness in the one being about 0.08 mm. and in the other between 0.03 and 0.04 mm. In the immediate vicinity of the centers the radii are slightly swollen, and this character affords another point of difference.

In the typical form of the species the nuclei of the rays are widely separated and often difficult to distinguish from the points where the rays merely cross each other. The rays often appear to, and probably do, bifurcate, and, on the whole, seem to meander about without much order. Sometimes they suggest *Heteronema capillare,* in which there are no nuclei, but, as they are considerably finer than in that species, there is little excuse for confusing them.

Occurrence.—Buildwas beds of the Wenlock shales, Shropshire, England; Rochester shales, Lockport, New York.

Cat. No. 43,146, U. S. N. M.

VINELLA RADICIFORMIS CONFERTA Ulrich

(PLATE LXVIII, 5, 6)

1893. *Vinella radiciformis* var. *conferta* ULRICH, Geol. Minnesota, III, p. 113, fig. 8, *c, d.*

This variety or closely related species may be distinguished usually without much trouble by the much greater frequency of its nuclei, more numerous radii, and slightly thicker threads. In the larger nuclei the center is commonly depressed. As to the radial threads, they are sometimes jointed, and in such cases each of the rather short internodes carries a single pore.

Occurrence.—Waldron shale, Waldron, Indiana.
Cat. No. 43,147, U. S. N. M.

VINELLA? MULTIRADIATA new species

(PLATE LXVIII, 8)

The specimen on which this peculiar species is founded incrusts a crinoid column, about three-fourths of an inch in length, about two-thirds covered with the supposed *Vinella.* At intervals varying from little more than 0.5 mm. to about 2.0 mm. the surface of the incrusting sheet presents subcircular, cup-shaped depressions, 0.12 mm. to 0.2 mm. in diameter, enclosed by a low rim from which 14 to 20 closely arranged threads proceed in all directions. The radii are commonly disposed in sets of three to five, those emanating from neighboring centers overlapping and interweaving in the interspaces. The sheet seems to consist in most parts of at least two superposed layers. Minute details of structure not preserved.

At first sight, under a low power of magnification, the specimen recalled the attached basal disks of articulating Bryozoa like *Arthropora* and *Escharopora,* but it soon became evident that the resemblance was deceptive and extended only to the common possession of cup-shaped depressions and lines radiating from them. Under a higher power the radii proved to be simple threads and not radially arranged walls separating rows of elongated zoœcial apertures, which is the structure of the attached disks of the articulating Bryozoa referred to. Of course the much smaller size of the *Vinella* was apparent from the beginning of our investigations. Though now thoroughly satisfied that we are not dealing with bases of zoaria, we think it quite possible that they may prove to be the bases of isolated zoœcia. Whatever the future may prove it to be, it impresses us as a very interesting organism, and it is the hope that other collectors may succeed in finding more and better specimens that has induced us to describe it.

Occurrence.—Rochester shale, Lockport, New York.
Cat. No. 43,144, U. S. N. M.

VINELLA? RADIANS (Nicholson and Etheridge, Jr.)

(PLATE LXV, 9, 10)

1877. *Ascodictyon radians* NICHOLSON AND ETHERIDGE, JR., Ann. & Mag. Nat. Hist., ser. 4, XIX, p. 465, pl. 19, figs. 9–11.
1887. *Ascodictyon radians* VINE, Proc. Yorkshire Geol. & Polyt. Soc., IX, p. 184.
1892. *Ascodictyon radians* VINE, Ibid., XII, p. 90.
Not *Ascodictyon radians ?* VINE, 1881 (=*Vinella radiciformis* (VINE)).

Having no specimens of this species, we can do no better than to republish the following original description and remarks by Nicholson and Etheridge, Jr. (loc. cit.):

"*Spec. char.* Colony composed of elongated vesicles, broad at their bases, thickened out in the middle of their length, and gradually attenuated towards their extremities, disposed in stellate clusters or rosettes. The bases of the tongue-like or somewhat fusiform vesicles are placed round a central circular depression; and their length varies from a sixth to more than a fourth of a line. Each rosette consists of from ten (sometimes fewer) to fifteen or twenty vesicles; and the free surface of each carries a single median row of excessively minute, somewhat slit-like, closely approximated pores. The rosettes are connected together by delicate creeping filaments, which may spring from the bases of the rosettes or from the attenuated extremities of the vesicles, and which generally anastomose, so as to form a network or mycelium.

"*Obs.* In its general structure and arrangement this species is related to *A. stellatum,* though sharply distinguished by the very elongated form of the vesicles and the presence of but a single row of pores on each. All the rosettes, when well preserved, show a circular central cavity or depression, with a distinct bounding wall; but we have been unable to make out the true nature of this, or its relation to the vesicles. When the vesicles are very numerous, they are smaller in size than when the rosette consists of fewer; but in all cases each shows a dark median line, which, when highly magnified, resolves itself into a line of minute close-set pores. The stolons may ramify and form a network; or a single stolon, proceeding directly from the end of a vesicle in one rosette, may be prolonged at once into the attenuated termination of a vesicle belonging to another rosette. Weathered specimens show clearly that the vesicles are traversed by a long tubular cavity, corresponding in form with the shape of these structures themselves; and they sometimes show what appear to be apertures at their bases. The stolons also are, doubtless, tubular, and they probably carry a median row of pores on their free faces, though we have not been able to determine either of these points to our satisfaction."

Judging principally from the published figures, of which we present tracings reduced one-third, this remarkable species cannot remain in the genus *Ascodictyon* as restricted by us. As remarked under the preceding generic description, the species is nearer *Vinella* than *Ascodictyon,* and it is here that we propose to place the species until its reëxamination proves it to belong elsewhere. So far as its char-

acters are known, the outward taper of the rays indicates relations with *V. radiciformis,* while in the number of its rays, in the central depression, and in its general expression it seems to agree better with our *V. ? multiradiata.*

Occurrence.—Lower Carboniferous of Scotland.

Genus HETERONEMA new genus

? 1892. *Vinella* (part) VINE, Proc. Yorkshire Geol. and Polyt. Soc., XII, pp. 84, 85.

Zoaria, so far as known, consisting of usually simple, or locally jointed, delicate, sparsely ramifying, tubular, creeping threads, arranged without apparent order. Pores rarely observed, apparently always in a single row.

Genotype.—*H. capillare* new species.

This, the most simple type of the family, has been confounded with *Vinella,* but we believe it necessary to distinguish it because of its extremely simple structure, and particularly on account of the absence of the highly characteristic nuclei, and consequent radial arrangement of the threads of *Vinella.* Regarding these nuclei as an essential feature of *Vinella,* we are enabled to present a more satisfactory and clearer definition of the genus than would be possible if species were included in which they are absent.

We have so far observed only three species of this type, and one of them is doubtful. The doubtful species is from Ordovician rocks, the genotype seems to be a common fossil in the Silurian of Gotland, and the third species a rare one in the basal part of the Coal Measures of Illinois. It is scarcely to be doubted that other forms will turn up when collections from intervening rocks are thoroughly searched.

HETERONEMA CAPILLARE new species

(PLATE LXV, 11)

Compare *Vinella repens* var. *contorta* VINE, Proc. Yorkshire Geol. and Polyt. Soc., XII, 1892, p. 85, pl. III, figs. 5–7.

Irregularly meandering threads, growing over shells and corals, sometimes scattering, at other times growing so abundantly that the crossing of the threads produces an irregular network. Threads tubular, slightly compressed, of uniform size, 0.035 mm. to 0.04 mm. thick, locally jointed. Pores not observed.

This form is readily distinguished from associated remains of Ctenostomatous Bryozoa by its delicate, irregularly intertwining, simple, creeping threads, which form colonies varying from a few scattering threads to patches an inch in diameter. It is possible that

1887. *Rhopalonaria* (part) VINE, Proc. Yorkshire Geol. & Polyt. Soc., IX, p. 185, pl. 12, fig. 11 (? 12).

Fossil zoaria of which only the creeping base is known. This attaches itself to foreign bodies and consists of strings of sausage-like, bulbous fusiform or pear-shaped internodes or vesicles varying greatly in size in different species. Surface of internodes minutely punctate, while a number in each colony exhibit a larger pore-like depression, usually near one end of the vesicle or internode that is regarded as marking the point where erect zoœcia were attached.

Genotype.—Allonema botelloides new species.

The distinctive features of this genus, when compared with *Heteronema, Vinella,* and *Rhopalonaria,* are (1) the separation of the creeping base into distinct vesicles or connected internodes, and (2) the minutely punctate surface of same. The second character has been observed in all the species now referred to the genus except *A. ? minimum.* In distinguishing the various species we have been obliged to rely chiefly on differences in the size of the internodes. However, a certain average seems constant for each species, so that we have experienced little difficulty in classifying our collections.

A. fusiforme (Nicholson and Etheridge, Jr.) and our *A. subfusiforme* and *A. waldronense,* are closely related but depart in size of form and internodes obviously from the more typical Silurian and Devonian species of the genus. The latter compare in the form of their internodes with *Valkeria,* the former remind more of the basal vesicles of *Ætea.* As the zoœcial characters of these two recent genera are different enough to cause them to be widely separated in the classification of the Bryozoa, it is possible that these fossil bases likewise belong to zoaria with very distinct zoœcia. However, it will perhaps forever be impossible to determine this point, and our only reason for referring to the possibility is the wish to avert off-hand unfavorable criticism of our "species." These may in some cases appear to be drawn too fine, but we think not, and for two reasons: In the first place, all we have of these Bryozoa are the creeping bases to which the erect and solitary zoœcia were attached. In classifying recent Ctenostomata, very little dependence is placed on the bases, the family, generic, and even specific characters being derived almost entirely from those of the zoœcia. Our second reason is the unlikelihood of one and the same species passing from one geological system to the next, as, for instance, from the Silurian to Middle or Upper Devonian.

Concerning the systematic position of the new genus, it seemed at first that the punctate surface of the internodes, and their frequent isolation in some of the species, should be regarded as the determining

factors, and cause its reference to the *Ascodictyonidæ*. On further reflection, however, the absence of the delicate threads which connect the clustered or isolated vesicles in *Ascodictyon* appeared a more important factor and induced us to classify the genus with the *Vinellidæ*.

ALLONEMA BOTELLOIDES new species

(Plate LXVII, 2–4)

In this species the internodes form strings of oblong, usually short, sausage-shaped links, averaging about 0.5 mm. in length and varying little from 0.25 mm. in width. In a colony holding this average, many of the links may be merely a little constricted or quite divided about the mid-length, while others may not be clearly divided from the next following links. Others again, especially where the links are crowded, will be abnormally narrow. Still, these variations do not seriously affect the general average of size and form of the internodes, nor the general aspect of the colony that is sufficiently characteristic to enable the observer to recognize the species at a glance. Traces of the surface puncture are nearly always preserved, but the larger zoœcial pore is not so often seen. In excellently preserved examples, less than half of the internodes exhibit evidence of having supported zoœcia.

Colonies of this species vary from a few internodes to others spreading over a space an inch or more across. They are readily distinguished from the associated *A. botellus* (Vine) by their more robust aspect, and proportionately shorter internodes.

Occurrence.—Common on corals in the Silurian of the Island of Gotland.

Cat. No. 43,126, U. S. N. M.

ALLONEMA BOTELLUS (Vine)

(Plate LXVII, 1)

1884. *Rhopalonaria botellus* Vine, Ann. & Mag. Nat. Hist., ser. 5, vol. xiv, p. 85, fig. iv, 3; 1887, Proc. Yorkshire Geol. & Polyt. Soc., vol. ix, p. 185; pl. 12, figs. 11 (?12).

This species is associated with the genotype in the Silurian rocks of Gotland, and the two forms not infrequently occur on the same coral or shell. We have, however, experienced no serious difficulty in distinguishing them, Vine's species having always a decidedly more delicate aspect. The average lengths of the internodes is about the same in both, but on account of their lesser width in *A. botellus*, in which this dimension usually varies between 0.1 mm. and 1.15 mm., they are proportionately more elongate than in our *A. botelloides*.

Some internodes in most colonies of this species are distinctly club-shaped, and these usually exhibit a zoœcial attachment pore.

Occurrence.—Silurian, Island of Gotland. Buildwas beds of Wenlock shales, England.

Cat. No. 43,125, U. S. N. M.

ALLONEMA MONILIFORME (Whiteaves) and var. AGGREGATUM new variety

(PLATE LXV, 14; PLATE LXVII, 9)

1891. *Stomatopora moniliformis* WHITEAVES, Cont. to Canadian Paleontology, vol. 1, p. 212, pl. 28, fig. 10.

Original Description.—" Polyzoary minute, creeping, attached by the whole of its under surface to some foreign object, very slender and fragile, consisting of a few irregularly disposed but more or less divergent rows of single cells, which, though uniserial, occasionally throw off lateral buds consisting of one or more cells, and which may, as in the specimen figured, proceed from a central or subcentral irregular aggregation of cells. Cells moderately convex, elliptical in marginal outline, averaging half a millimetre in length, about one third longer than broad and placed end to end: apertures of the cells nearly terminal, extremely minute, simple and consisting of mere rounded perforations in the cell wall. Surface smooth."

The above description brings out several points showing that the species cannot be a *Stomatopora*. That both the description and figures given by Whiteaves faithfully record the facts can be attested by the senior author of this paper who, in 1890, saw the four specimens upon which the species was shortly thereafter established. At that time the latter failed to recognize the true affinities of the specimens, but now, since we have studied all the known Paleozoic forms of this peculiar type of Bryozoa, we have not the least hesitation in pronouncing *Stomatopora moniliformis* a species of *Allonema*. Specifically it is closely allied to our *A. botelloides,* but differs in the slightly greater average width and more bead-like form of its internodes. The small, subcentral aggregation of vesicles is another feature that may assist in separating the species from the Silurian type of the genus.

Variety AGGREGATUM new variety

Under this name we propose to distinguish a variety of *A. moniliforme* that is represented in the Ulrich collection by a single, well-preserved example from the Hamilton formation in Genesee county, New York. It is a patch about 1 cm. in diameter, attached to a small coral, and consists, as may be seen in plate LXVII, 9, of a closely

arranged and somewhat radially disposed series of sharply defined internodes or vesicles. The latter vary greatly in size, both as to width and length, and also in form. Only the larger series project beyond the central or denser part of the colony.

Occurrence.—The typical form is from the horizon of *Schizophoria striatula* in the Devonian, on Hay river, Canada, 40 miles above its mouth. Variety *aggregatum* is from the Hamilton formation, in Genesee county, New York.

Cat. No. 43,131, U. S. N. M.

ALLONEMA WALDRONENSE new species

(Plate LXVII, 5)

Colonies small, consisting of an irregular, winding series of comparatively few and rather large, inflated internodes. The series branches occasionally, and a few of the internodes appear to be quite isolated. The internodes vary greatly in form, some being globular or elliptical, others pyriform, and a few of the largest bilobate. The last probably consist of two partially confluent vesicles. With all this variation, the internodes still remain within reasonable distance of the average size that we consider characteristic of the species. The average length may be placed at about 0.5 mm., the width at 0.3 mm.

So far as the size of the internodes is concerned, they are no larger than in *A. moniliforme* (Whiteaves) and only a little larger than in *A. botelloides,* but their bulbous and irregular shapes and the narrow necks connecting them cause them to look very different. The true affinities of *A. waldronense* doubtless lie with *A. fusiforme* (Nicholson and Etheridge, Jr.) and our *A. subfusiforme.* It is, however, readily distinguished from both by its smaller internodes.

Occurrence.—Waldron shales of the Niagaran group, Waldron, Indiana.

Cat. No. 43,128, U. S. N. M.

ALLONEMA SUBFUSIFORME new species

(Plate LXVII, 6, 7)

Colonies small, of few large internodes, the series branching irregularly. Internodes normally bottle-shaped, with a narrow connecting neck, varying greatly in size, the largest 1.0 mm. in length and 0.6 mm. in width, the smallest only about 0.4 mm. long by 0.22 mm. wide. The largest internodes usually at the distal extremities of the branches, the smallest at the proximal ends. Average size of internodes about 0.7 mm. in length and 0.4 mm. in width.

This species is distinguished from *A. waldronense,* which occupies a nearly equivalent geological horizon in America, only by the larger average size and rather more regular form of its internodes. In the matter of size it agrees more nearly with the Devonian *A. fusiforme* (Nicholson and Etheridge, Jr.), but its internodes are rarely, if ever, isolated, and when normally developed they are bottle-shaped rather than fusiform.

Occurrence.—Silurian, Island of Gotland.

Cat. No. 43,127, U. S. N. M.

ALLONEMA FUSIFORME (Nicholson and Etheridge, Jr.)

(PLATE LXVII, 8)

1877. *Ascodictyon fusiforme* NICHOLSON AND ETHERIDGE, JR., Ann. & Mag. Nat. Hist., ser. 4, vol. XIX, p. 463, pl. 19, figs. 7, 8.

1892. *Ascodictyon fusiforme* VINE, Proc. Yorkshire Geol. & Polyt. Soc., vol. XII, p. 89.

Plate LXVII, 8, represents the greater part of a very characteristic example of this species. Often many of the internodes or vesicles are quite isolated, but more generally they just touch one or more of their neighbors. The most common shape is fusiform, others ovate, while a greater or smaller number in each colony are joined together by rather long necks. As usual in species of this genus, the whole surface is distinctly punctate, but in no case have we observed a point where an erect zoœcium might have been attached.

The principal distinctive features of this species are the frequent isolation of the internodes and their normally fusiform shape.

Occurrence.—Hamilton formation, Alpena, Michigan; Falls of the Ohio; Thedford (Widder), Ontario.

Cat. No. 43,129, U. S. N. M.

ALLONEMA? MINIMUM new species

(PLATE LXVII, 10–12)

Small colonies consisting of frequently bifurcating series of subglobular, ovate, or more or less elongate pyriform vesicles, generally about 0.1 mm. in width and varying in length, according to the degree in which the proximal end is drawn out, from 0.1 mm. to 0.28 mm. The pyriform cells usually carry a minute pore and remind of the zoœcia of Ordovician species of *Stomatopora,* like *S. inflata.* No pores of any kind were observed on the subglobular vesicles. Aside from the single pore that occurs on most of the pear-shaped cells, these also exhibited no trace of the surface punctation observed in all the other species referred to this genus.

We are not satisfied that this neat but very minute species is properly classified, but, as no fitter disposition suggested itself, we trust the arrangement may suffice until increasing knowledge enables us to fix its systematic position definitely.

Occurrence.—Upper Coal Measures, Springfield, Illinois.

Cat. No. 43,124, U. S. N. M.

Family ASCODICTYONIDÆ Ulrich (restricted)

From the viewpoint of the systematist, perhaps the most notable result of this revision of the Paleozoic Ctenostomata is the restriction of this family to the typical genus. Something of this sort, however, was to be expected, since the classification of these obscure bryozoan remains hitherto in force was always regarded as a most provisional arrangement.

Genus Ascodictyon Nicholson and Etheridge, Jr.

1877. *Ascodictyon* (part) Nicholson and Etheridge, Jr., Ann. & Mag. Nat. Hist., ser. 4, xix, p. 463.
1881. *Ascodictyon* Vine, Quart. Jour. Geol. Soc. London, xxxvii, p. 618.
1882. *Ascodictyon* Vine, Ibid., xxxviii, p. 52.
1884. *Ascodictyon* Vine, Rep. 53d Meeting Brit. Assoc. Adv. Sci., p. 185.
1884. *Ascodictyon* Vine, Ann. & Mag. Nat. Hist., ser. 5, xiv, p. 78.
1887. *Ascodictyon* Vine, Proc. Yorkshire Geol. & Polyt. Soc., ix, p. 183.
1889. *Ascodictyon* Miller, North Amer. Geol. and Pal., p. 293.
1890. *Ascodictyon* Ulrich, Geol. Surv. Illinois, viii, p. 367.
1892. *Ascodictyon* Vine, Proc. Yorkshire Geol. & Polyt. Soc., xii, p. 86.
1897. *Ascodictyon* Simpson, Fourteenth Ann. Rep. State Geol. New York for 1894, p. 603.
1900. *Ascodictyon* Nickles and Bassler, Bull. U. S. Geol. Surv., No. 173, p. 19.

Zoaria parasitic, consisting of ovate or pyriform vesicles, arranged in radial clusters or isolated, and connected with each other by very delicate, hollow threads. Walls of vesicles perforated by closely arranged, minute pores. Zoœcia unknown.

Genotype.—*A. stellatum* Nicholson and Etheridge, Jr.

Although *A. fusiforme* follows the generic description in the original publication, and for that reason is usually cited by cataloguers as the genotype, it is very evident that the authors of the genus regarded *A. stellatum* as the type. This is shown by the italicized words in the following quotation from their generic diagnosis: "In some cases they [the vesicles] open into one another by short contracted necks or stolons, thus forming a loosely reticulate network; whilst *more typically* they are arranged in regular, usually stellate clusters, which in turn are united with one another by delicate thread-like hollow

tubes, which often ramify and anastomose." The matter of selecting and fixing the genotype is important for the reason that we refer *A. fusiforme* to our new genus *Allonema*, while Nicholson and Etheridge's third species, *A. radians*, is removed provisionally to *Vinella*.

The restriction of *Ascodictyon* to species agreeing strictly with the adopted type *A. stellatum*, renders it a compact and sharply defined genus. As now constituted, the only amendment still possibly defensible is the elimination of *A. filiforme* Vine and *A. sparsum*, one of our new species, in which the vesicles, if we leave the connecting threads out of consideration, are always isolated. In all the other species they are normally arranged in radial clusters. If it could be shown that this difference in the arrangement of the vesicles is of genetic significance, we should be strongly inclined to favor a separation. At present, however, we have no direct evidence bearing upon the point and must, therefore, regard the future restriction of the genus as unjustifiable. It may be worthy of remark, however, that even in *A. stellatum* at least some of the vesicles of many colonies are isolated or, rather, scattered without definite relation to each other.

So far as known, the first species of this genus occur in the Silurian, *A. siluriense* Vine being found, together with *A. filiforme* Vine, in the Wenlock shales of England, and the former species also in the Rochester and Waldron shales of this country. The shales of the Hamilton formation also afford two species, the genotype *A. stellatum* and a new form for which we propose the name *A. floreale*. The shales of the Chester group is the third and last horizon in which we have detected the genus, and, as in the two preceding cases, here again it is represented by two species, both new.

ASCODICTYON SILURIENSE Vine

(PLATE LXVIII, 11, 12)

1881. *Ascodictyon stellatum* VINE, Quart. Jour. Geol. Soc. London, XXXVII, p. 618.

1882. *Ascodictyon stellatum* var. *siluriense* VINE, Ibid., XXXVIII, p. 52, figs. 1, 2.

1884. *Ascodictyon stellatum* var. *siluriense* VINE, Ann. & Mag. Nat. Hist., ser. 5, XIV, p. 81.

1887. *Ascodictyon stellatum* var. *siluriense* VINE, Proc. Yorkshire Geol. and Polyt. Soc., IX, p. 184, pl. 12, fig. 6.

1892. *Ascodictyon siluriense* VINE, Ibid., XII, p. 88, pl. 2, fig. 1.

Vesicles pyriform, the small end more or less drawn out, 0.1 mm. to 0.2 mm. in diameter, and 0.3 mm. to 0.5 mm. in length, arranged

in clusters of four to eight, with clusters of four or five occurring oftener than six to eight. Connecting threads about 0.03 mm. in thickness, comparatively straight, with clusters of vesicles occurring at intervals of 2.5 mm. or more.

Compared with *A. stellatum,* this species is distinguished by its usually fewer and less closely arranged vesicles in each cluster, by the greater average length and more pyriform shape of the vesicles, and by the comparative rigidity of the connecting threads.

Occurrence.—Wenlock shale, Buildwas beds, Shropshire, England; Rochester shale, Lockport, New York; Waldron shale, Waldron, Indiana.

Cat. Nos. 43,135, 43,138, U. S. N. M.

ASCODICTYON STELLATUM Nicholson and Etheridge, Jr.

(Plate LXVIII, 9, 10)

1877. *Ascodictyon stellatum* Nicholson and Etheridge, Jr., Ann. & Mag. Nat. Hist., ser. 4, xix, p. 464, pl. 19, figs. 1–6.
1891. *Ascodictyon stellatum* Whiteaves, Contr. Canadian Pal., 1, p. 213.
1892. *Ascodictyon stellatum* Vine, Proc. Yorkshire Geol. & Polyt. Soc., xix, p. 89.
1893. *Ascodictyon stellatum* Ulrich, Geol. Minnesota, iii, p. 113, fig. 8a.
1897. *Ascodictyum stellatum* Simpson, Fourteenth Ann. Rep. State Geol. N. Y. for 1894, p. 603, fig. 220.
Not *Ascodictyon stellatum* Vine, 1881 (=*Ascodictyon siluriense* Vine).

Original description.—"Colony composed of ovoid or pyriform calcareous vesicles, varying in length from one fifth to one third of a line, and usually disposed in stellate clusters, each containing from three to six cells, or sometimes more. The walls of the vesicles are perforated by microscopic foramina, usually showing a distinctly linear arrangement. The clusters are connected together by creeping filamentous tubes, the free surfaces of which are perforated by a single row of minute foramina, and which generally anastomose so as to form a network."

This common and widely distributed species maintains its specific characters with great constancy. Still, it agrees too closely with certain specimens of *A. siluriense* to render their separation always easy. As a rule the Silurian species has fewer vesicles in its clusters, and these generally occur also at longer intervals. Again the inner ends of the vesicles are never drawn out in *A. stellatum* as is common in *A. siluriense.* Finally, in a close comparison, the connecting threads impress one as being less rigid in the Devonian species than in the older form.

Occurrence.—Hamilton formation, Eighteen Mile creek and other localities in New York; Thedford (Widder) and neighboring localities in Ontario.

Cat. No. 43,137, U. S. N. M.

ASCODICTYON FLOREALE new species

(PLATE LXVIII, 13)

Though easily distinguished from *A. stellatum,* this species differs in little or nothing save that it is considerably smaller. The average width of the flower-like clusters is only about 0.5 mm. while in *A. stellatum* they usually reach a diameter of nearly 1.0 mm. The clusters occur also at shorter intervals in *A. florcale,* the average distance from center to center being less than 1.0 mm. With specimens in hand these differences cannot fail to strike the observer at once.

Occurrence.—Hamilton formation, 2 miles west of Alpena, Michigan.

Cat. No. 43,136, U. S. N. M.

ASCODICTYON PARVULUM new species

(PLATE LXVIII, 14)

This species is characterized by its extreme minuteness and crowded habit of growth. Five to eight vesicles occur in each cluster, but in parts of the colonies they appear to be arranged without regard to any central point or points. As a rule these irregularly disposed vesicles are of less than the average size. Generally the clusters are less than 0.5 mm. apart, measuring from center to center. The vesicles are elliptical or pyriform in outline, and vary in length from 0.07 mm. to 0.12 mm.

Occurrence.—Chester group, Jackson county, Kentucky.

Cat. No. 43,143, U. S. N. M.

ASCODICTYON FILIFORME Vine

(Not figured)

1882. *Ascodictyon filiforme* VINE, Quart. Jour. Geol. Soc. London, XXXVIII, pp. 54–55.

1894. *Ascodictyon filiforme* VINE, Ann. & Mag. Nat. Hist., ser. 5, XIV, pp. 78–80.

1887. *Ascodictyon filiforme* VINE, Proc. Yorkshire Geol. & Polyt. Soc., IX, p. 183, pl. 12, figs. 1–4.

1892. *Ascodictyon filiforme* VINE, Ibid., XII, p. 86, pl. iii, figs. 8–15.

Vesicles not occurring in regular clusters, as in the more typical species of the genus, but developed at very unequal though generally short intervals from the sides of the connecting threads; occasionally

developed abundantly enough to simulate the radial clusters of the other species. Vesicles apparently of slightly smaller average size than in the associated *A. silurieuse* of the same author.

Occurrence.—Buildwas beds, Wenlock shales, Shropshire, England.

ASCODICTYON SPARSUM new species

(Plate LXVIII, 15)

This species is founded upon a single, but excellently preserved, colony attached to a species of *Polypora*. The vesicles contrast strongly with the host, being much darker—nearly black. In form they are ovate, appearing as highly inflated bulbs lying close to, in some instances apparently in contact with, one of the extremely fine threads that run in every direction over the surface of the *Polypora*, though mostly parallel with the length of its branches. Generally the vesicles are solitary; sometimes, however, they occur in pairs, while the interval between them is often greater than shown in our figure. In size they vary from 0.1 mm. by 0.15 mm. to 0.2 mm. by 0.25 mm.

Belonging to the section of the genus having solitary vesicles, this species need only be compared with Vine's *A. filiforme*. From this it is readily distinguished by the smaller size of its vesicles and greater delicacy of its connecting threads.

Occurrence.—Near top of Chester group, Claxton, Caldwell county, Ky.

Cat. No. 43,142, U. S. N. M.

ASCODICTYON YOUNGI Vine

(Not figured)

1892. *Ascodictyon Youngi* Vine, Proc. Yorkshire Geol. & Polyt. Soc., XII, p. 90, pl. 4, figs. 3, 4.

Original description.—"Zoarium composed of pyriform vesicles occasionally disposed in stellate cluster, similar to other species already described. These vesicles are connected together by filimentous, hollow, unornamented threads, which creep along and undulate with the irregularities of the surfaces to which the forms are attached. The type species is adherent to a portion of a Crinoid stem (*Platycrinus* sp.), and the stellate vesicles are not so abundant in their colonial growths as in the Silurian species."

Occurrence.—Carboniferous shales, Hairmyres, Scotland.

Position Doubtful

Genus Ptychocladia new genus

Parasitic, small patches, consisting of bifurcating and inosculating, transversely wrinkled, minute branches.

Genotype and only known species.—*Ptychocladia agellus* new species.

PTYCHOCLADIA AGELLUS new species

(PLATE LXVII, 10 (part), 13)

Beginning with a comparatively strong, curved stem, 0.2 mm. to 0.5 mm. in width, the colony continues its growth by addition of frequently dividing and coalescing depressed convex branches which increase in width from 0.1 mm. to 0.2 mm. or more, until an irregularly cribrose expansion, 3.0 mm. to 5.50 mm. in width, is produced. Basal stem and branches with transverse wrinkles, apparently composed of structureless, cemented, calcareous grains, which occasionally appear to have been combined so as to leave minute pores between them.

The minute structure of these fossils is very obscure, and their systematic position so doubtful that we are scarcely willing to hazard an opinion. Possibly they are algæ, or, if their branches are tubular, a point we did not succeed in determining, they may be related to some of the preceding forms. Again, they may prove to belong to some peculiar type of Foraminifera. Of these various possibilities, the first strikes us as the most plausible, though we are not by any means prepared to express a decided opinion.

Occurrence.—Upper Coal Measures, near Springfield, Ill. Associated with *Allonema ? minutum.*

Cat. No. 43,123, U. S. N. M.

EXPLANATION OF PLATES

PLATE LXV

(With the exception of figures 11 to 13, all of the illustrations on this plate were reproduced from rather crude tracings of previously published figures, and reduced one-third in the reproduction. Figures 1 to 8 are of recent species from Hincks' *British Marine Polyzoa,* figures 9 and 10 from Nicholson and Etheridge's work on *Ascodictyon,* and figure 14 from a paper by Whiteaves.)

FIG. 1. *Ætea anguina* Linnæus. Showing zoœcia arising from the creeping stem, × 16.

2. *Ætea truncata* (Landsborough). A portion of the creeping base, × 16.

(Figures 1 and 2 are introduced for comparison with *Allonema* and *Rhopalonaria*).

3. *Cylindrœcium dilatatum* Hincks, × 16.

4, 5. *Vesicularia spinosa* Linnæus, × 16 and × 28, to be compared with *Vinella* and *Heteronema.* Figure 4 represents the terminal portion of a branch from which most of the zoœcia have been stripped.

6. *Valkeria uva* Linnæus. Erect form, × 16, *Allonema* and *Ascodictyon* are to be compared with this genus.

7. *Arachnidium clavatum* Hincks, × 16, showing similarity to *Rhopalonaria.*
8. *Bowerbankia caudata* (Hincks), × 16, exhibiting arrangement of the deciduous zoœcia on the stolon.
   Vinella ? radians (Nicholson and Etheridge, Jr.).....p. 276
9. Colony, two-thirds natural size.
10. A nucleus with the radiating stolons, × 20.
    Carboniferous of England.
    Heteronema capillare genus and species new.....p. 278
11. Small part of a large colony, × 9, growing upon a strophomenoid shell. The threads sometimes cross each other, simulating the nucleus of a *Vinella,* while other threads appear to be jointed.
    Silurian, Island of Gotland.
    Heteronema ? contextum new species.....p. 279
12. Small part of a large colony, × 9, growing over the celluliferous face of a monticuliporoid bryozoan.
    Corryville beds, Lorraine formation, Morrow, Ohio.
    Heteronema carbonarium new species.....p. 279
13. Several of the creeping threads, × 9, growing upon a *Spirifer.*
    Lower Coal Measures, Seville, Ill.
    Allonema moniliforme (Whiteaves).....p. 282
14. A colony, × 6⅔.
    Devonian, Hay river, Canada.

Plate LXVI

(Unless otherwise mentioned, the figures on this plate are × 9.)

Arachnidium hippothooides Hincks.....p. 263

Fig. 1. Outline sketch of several zoœcia of this living species, × 16, introduced for comparison with species of *Rhopalonaria.* (After Hincks, *British Marine Polyzoa*).
   Rhopalonaria venosa Ulrich.....p. 268
2. Portion of the reticulate zoarium of this species growing upon a pelecypod. The substance of the zoarium is replaced by pyrites.
3. Part of a colony with broader zoœcia than usual, encrusting *Rafinesquina alternata.*
   Lower beds of Richmond formation, Waynesville, Ohio.
   Rhopalonaria attenuata new species.....p. 269
4. Part of a colony preserved as an excavated mold, with several branches growing so as to intersect each other, thus causing an apparent irregularity in the growth.
5. Portion of another colony preserved as an excavated mold on a gastropod, showing a more regular arrangement of the zoœcia. Both figures illustrate the extreme tenuity of the connecting stolons and the very slight swelling of the zoœcial part.
   Rochester shales, Lockport, New York.
   Rhopalonaria robusta new species.....p. 269
6. The greater part of a colony illustrating the comparatively large size and general form of the zoœcia.
   Oriskany (Camden chert), Camden, Tennessee.

Rhopalonaria tenuis new species.....p. 270

7. Portion of a colony growing on a *Stropheodonta* and showing a rather irregular growth and the attenuate fusiform shape of the zoœcia.

Hamilton formation, Thedford, Ontario.

8. The excavated mold of a normally developed colony.

9. The excavated mold of another colony in which the zoœcia are crowded on account of the frequent crossing of the branches. Doubtfully referred to this species.

Hamilton formation, Alpena, Michigan.

Rhopalonaria medialis new species.....p. 270

10. Portion of a colony attached to the same shell bearing the specimen illustrated by figure 7.

Hamilton formation, Thedford, Ontario.

Rhopalonaria keokukensis new species.....p. 272

11. Portion of a large colony of which the excavated mold only is preserved, covering the greater part of a *Zaphrentis*.

Keokuk formation, Keokuk, Iowa.

PLATE LXVII

(Unless otherwise specified, the figures on this plate are × 9.)

Allonema botellus (Vine).....p. 281

FIG. 1. Portion of a colony attached to the dorsal valve of *Leptæna rhomboidalis*.

Silurian, Island of Gotland.

Allonema botelloides new species.....p. 281

2, 3. Portions of two colonies, one growing upon *Goniophyllum pyramidatum* and the other upon a cyathophylloid coral.

4. One of the vesicles of figure 3, × 18, showing a pore or pit near one end and the small pores of the test.

Silurian, Island of Gotland.

Allonema waldronense new species.....p. 283

5. Portion of a colony attached to the dorsal valve of an orthoid.

Waldron shales, Waldron, Indiana.

Allonema subfusiforme new species.....p. 283

6. The greater part of a colony attached to *Goniophyllum pyramidatum*.

7. One of the vesicles of same, × 18, showing the punctate surface.

Silurian, Island of Gotland.

Allonema fusiforme (Nicholson and Etheridge, Jr.).....p. 284

8. A small part of a colony. Only one vesicle is drawn to show the punctæ of the surface. The specimen is growing upon the poriferous side of a small *Polypora*.

Hamilton formation, Alpena, Michigan.

Allonema moniliforme var. *aggregatum* new variety.....p. 282

9. Portion of a colony growing upon a *Diphyphyllum*. The figure shows the close arrangement of the rows of vesicles.

Hamilton formation, Genesee county, New York.

Allonema ? minimum new species.....p. 284

10. The greater part of a colony with a young specimen of *Ptychocladia agellus* running from the lower to the middle part of the figure.

11. A series of vesicles of same, × 18, showing variations in form and the aperture-like pit in four of them.

12. Another series of the same, × 18, showing further variations in form of the vesicles.
Upper Coal Measures, Springfield, Illinois.
Ptychoclodia agellus new genus and species.....p. 290
13. The most complete of the specimens upon which this remarkable genus and species is founded. See also figure 10.
Upper Coal Measures, Springfield, Illinois.

Plate LXVIII

(Figures 1 to 6 and 9 are after Ulrich in Pal. Minn., III, Pt. 1.)

Vinella repens Ulrich.....p. 274

Fig. 1. Two colonies attached to the inner side of a ventral valve of *Strophomena septata* W. & S.; natural size.
2. Portion of one of the colonies, × 18.
3. Another portion of the same zoarium, × 18, showing a nucleus with five divisions of the tubular stolons radiating from it.
Black River shales, St. Paul, Minn.
Vinella radialis Ulrich.....p. 274
4. Natural size view of the type specimen.
Corryville beds, Lorraine formation, Cincinnati, Ohio.
Vinella radiciformis conferta Ulrich.....p. 275
5. Several nuclei and the connecting stolons, × 18.
6. Part of a colony, × 4½, showing the close development of the nuclei.
Waldron shales. Waldron, Indiana.
Vinella radiciformis (Vine).....p. 275
7. Portion of the creeping network of the typical form of this species, × 9, showing several nuclei.
Rochester shales, Lockport, New York.
Vinella? multiradiata new species.....p. 276
8. Part of a colony attached to a crinoid column, exhibiting many nuclei and the intertwining of the numerous radiating stolons, × 9.
Rochester shales, Lockport, New York.
Ascodictyon stellatum Nicholson and Etheridge, Jr.....p. 287
9, 10. Two clusters, × 18 and × 9. Only one of the vesicles in the first figure has the surface punctæ represented.
Hamilton formation, Eighteen Mile creek, New York.
Ascodictyon siluricuse Vine.....p. 286
11. Two isolated clusters of vesicles, × 9, attached to a fragment of *Leptæna rhomboidalis*.
Rochester shales, Lockport, New York.
12. A number of clusters of vesicles with connecting stolons, × 9, growing on a small *Orthoceras*.
Waldron shales, Waldron, Indiana.
Ascodictyon floreale new species.....p. 288
13. Portion of a colony with numerous clusters of vesicles, × 9, growing upon a *Stropheodonta*.
Hamilton formation, 2 miles west of Alpena, Michigan.

Ascodictyon parvulum new species.....p. 288

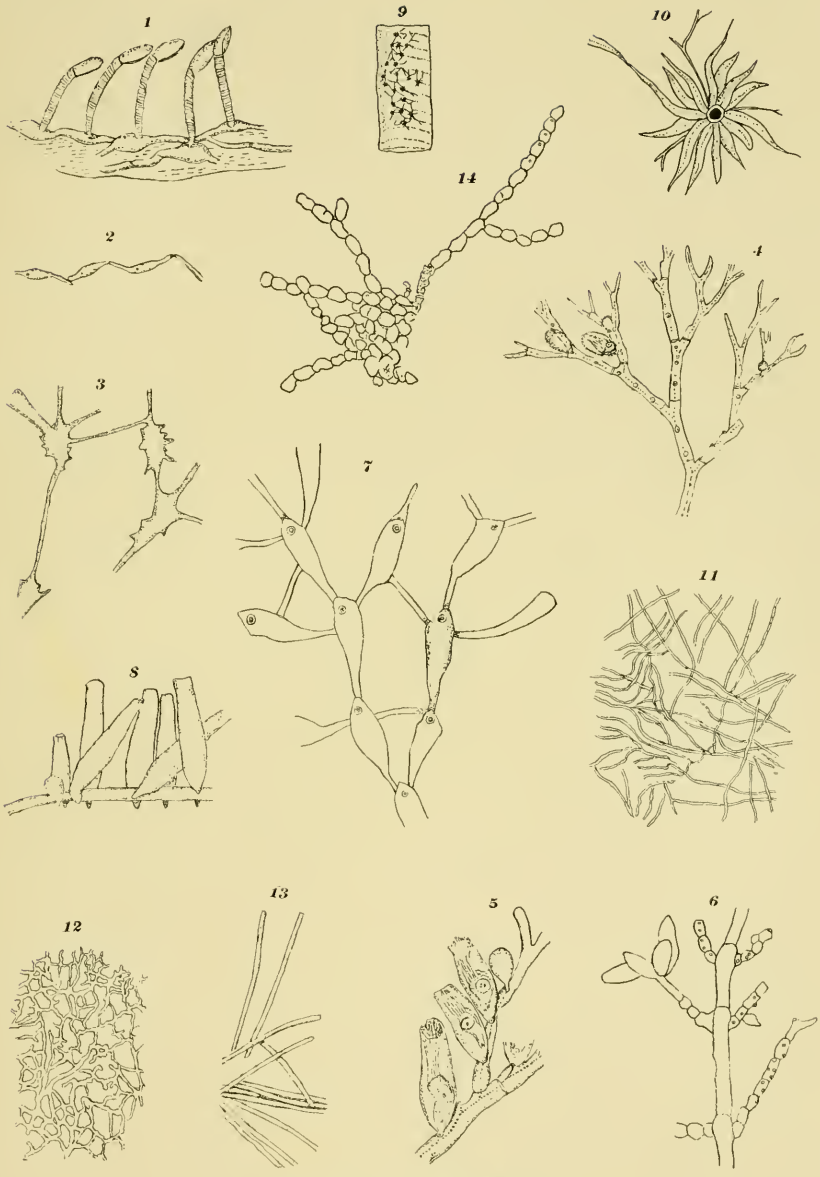
14. Part of a colony, × 9, growing upon a crinoid column, showing vesicles arranged in clusters and others apparently without order.

Chester formation, Jackson county, Kentucky.

Ascodictyon sparsum new species.....p. 289

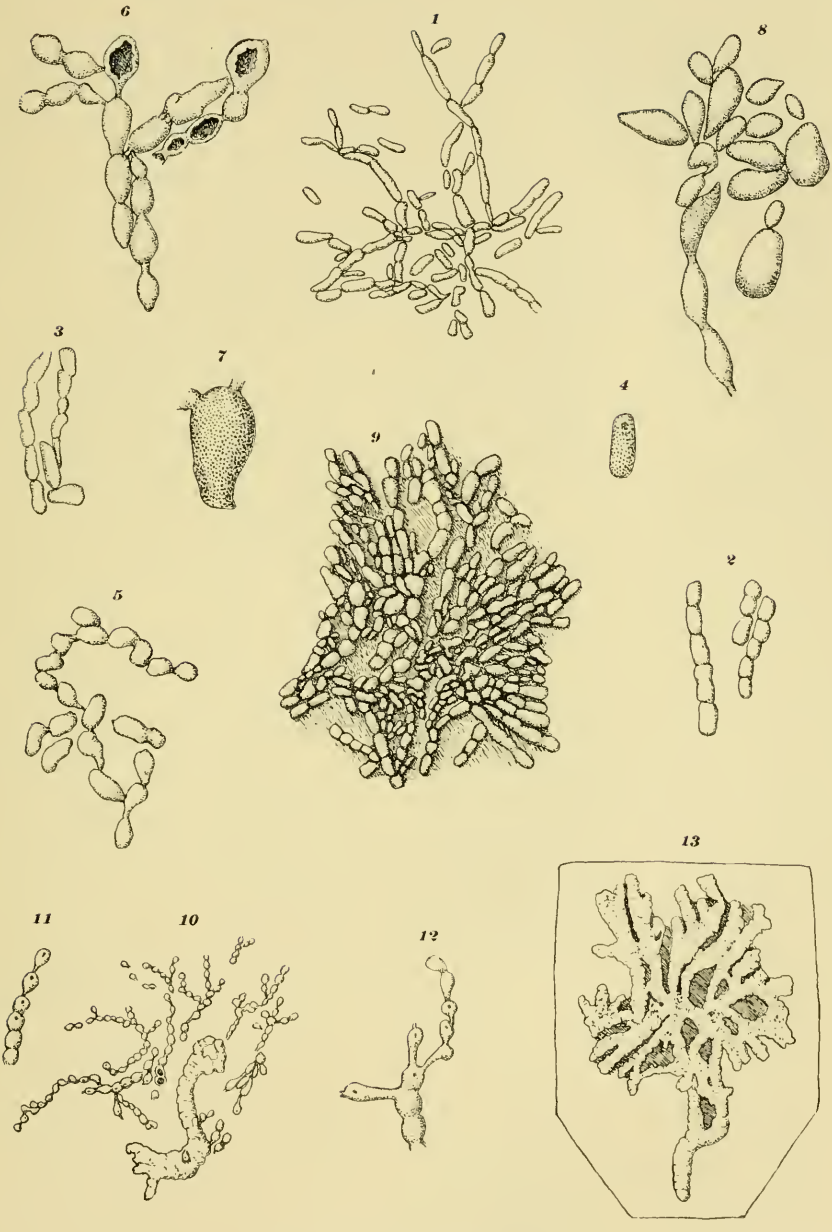
15. Several branches of the adnate colony, showing the usual scattered arrangement of the vesicles, × 9. The connecting stolons are not so clearly shown in the specimen as in the figure.

Chester formation, Claxton, Caldwell county, Kentucky.

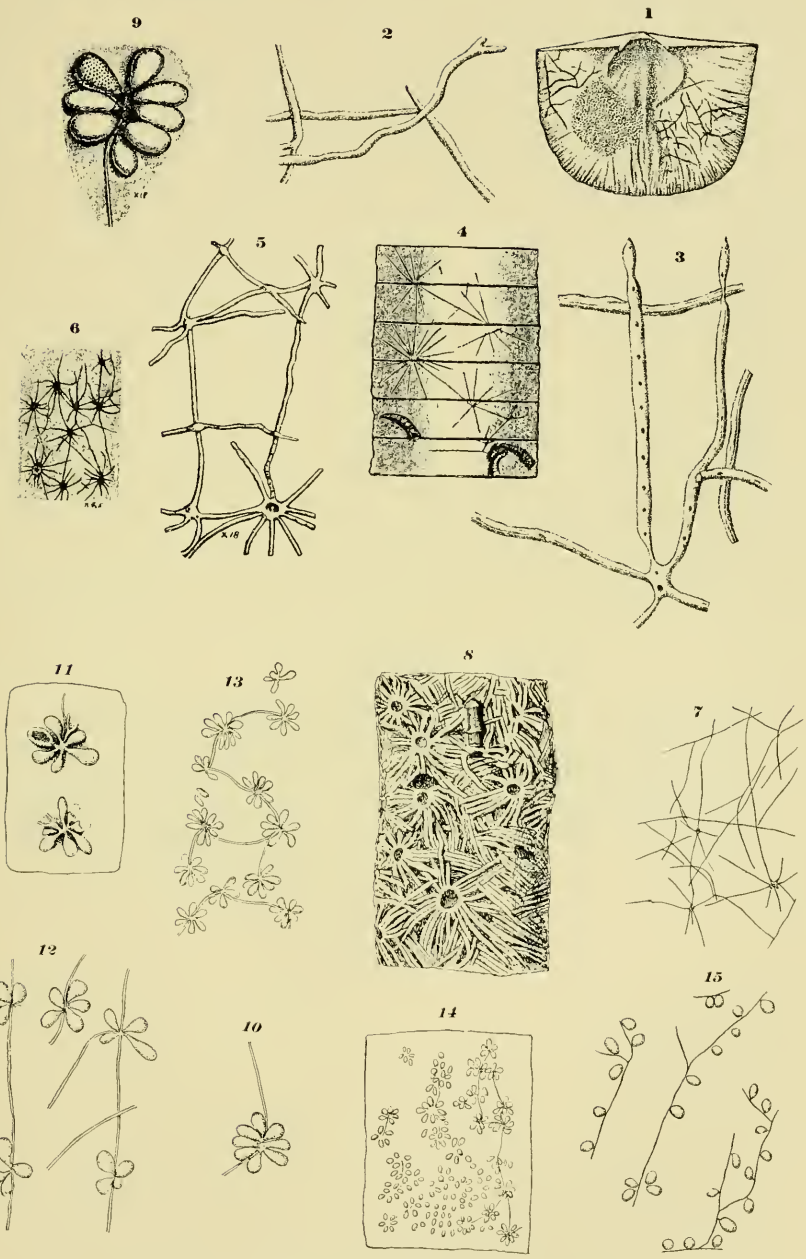


SPECIES OF CTENOSTOMATA.

SPECIES OF CTENOSTOMATA.



SPECIES OF CTENOSTOMATA.



SPECIES OF CTENOSTOMATA.