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GEOLOGICAL SURVEY OF ILLINOIS,

A. H. WORTHEN, DIRECTOR.

VOLUME VIII.

GEOLOGY AND PALÆONTOLOGY.

Edited by JOSUA LINDAHL, Ph. D., State Geologist.

GEOLOGY,

BY A. H. WORTHEN.

PALÆONTOLOGY,

BY A. H. WORTHEN, CHARLES WACHSMUTH, FRANK SPRINGER, E. O. ULRICH AND OLIVER EVERETT.

WITH AN APPENDIX.

TEXT.

PUBLISHED
BY AUTHORITY OF THE LEGISLATURE OF ILLINOIS.
JULY, 1890.

ILLUSTRATED
BY E. O. ULRICH,
NEWPORT, KENTUCKY.

PRINTED
BY H. W. ROKKER,
SPRINGFIELD, ILLINOIS.

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LETTER OF TRANSMITTAL.

To His Excellency, JOSEPH W. FIFER,

Governor of Illinois:

SIR:—

I have the honor to submit herewith the Eighth Volume of the Geological Survey of Illinois.

This volume, exclusive of the "Appendix," was prepared by the late Professor A. H. WORTHEN, in accordance with an Act of the Thirty-Fourth General Assembly of the State of Illinois, approved June 27, 1885, which provided *"That the Curator of the State Historical Library and Natural History Museum, who is required to perform such duties as may be by law required of the State Geologist, shall during the ensuing two years, collect and prepare for publication a volume ...... to be entitled Volume 8 of the Geological Survey of Illinois."* For certain reasons the contract with the State Printer was not signed until late in 1888, and in this interval Professor WORTHEN had died, May 6th, 1888. My commission as his successor, bears the date of June 9th of the same year, and it became my duty to edit this volume.

The printing was commenced early in 1889. Neither I, nor any of the authors could have foreseen that more than a year and a half would be needed for its completion. The new genera described in Part II, Section 3, bear the date of 1889, which, as it now happened, is apparently a case of antedating. However, as all the new species in the volume were recorded in Mr. S. A. MILLER'S "*North American Palæozoic Fossils,*" which work was published in November, 1889, this may be taken as an excuse for omitting corrections of the above dates, in the "Errata."

The plates illustrating Part II, were printed before Prof. WORTHEN'S death. Mr. CHAS. K. WORTHEN made the original drawings for plates IX-XXVIII, the remaining 58 were drawn by Mr. E. O. ULRICH, who also contracted for and lithographed all the 78 plates. The KREBS Co. did the printing. Mr. ULRICH informs me that a strike among the pressmen, and the consequent necessity of employing inexperienced hands in printing plates XXXVIII-LX, was the cause of the less satisfactory appearance of these plates.

As this volume not only forms the final report of the Geological Survey of Illinois, but also represents the last work of its venerable Director, it seems appropriate to close these eight volumes with a biographical sketch and portrait of Prof. WORTHEN, and to add a general index to the entire series of his reports.

Mr. N. W. BLISS, Attorney at Law, a near relative of the deceased and his most intimate friend from childhood, was requested, at the suggestion of Prof. WORTHEN'S family, to sketch his private life, and Prof. C. A. WHITE, M. D., of the United States Geological Survey, to likewise treat the scientific work of Prof. WORTHEN, and both of them willingly responded. Their sketches will be found in the "Appendix."

It is my pleasant duty hereby to render thanks officially to the heirs—the 6 sons—of Professor WORTHEN, who defrayed all expenses for the excellent portrait of their lamented father, which adorns the "Appendix." The original pen-and-ink drawing by the eminent artist JACQUES REICH, of New York, which drawing is the property of this office, was placed at their disposal for the purpose of being reproduced.

The index of the PALÆOCRINOIDEA in Vol. VIII, Part II, Sections 1 and 2, was revised by Mr. CHARLES WACHSMUTH, and those of the SPONGIÆ and BRYOZOA in Sections 3-6, by Mr. E. O. ULRICH. In preparing the "General Index," I at first simply consolidated the indices of the eight volumes into one. But finding that such a consolidation would by no means answer the purpose, I undertook to revise every item and make numerous additions and re-arrangements, as well as orthographic corrections of palæontological names. This extremely tedious and time consuming work was done last fall when I had reasons to hope that the volume would be published before the end of last year. The index is therefore less elaborate than I would have made it, had I known then that I could spend much more time on it without delaying the printers. As it is, I trust it will still be found of value.

The Geological Map of Illinois, published in 1875, and distributed with Vol. VI, of these reports, has long been out of print, and I have been unable to fill the frequent requisitions from scientists, schools, libraries and private applicants, most of whom have stated that they have the set of reports but not the map. I have therefore added to this volume a reproduction of the old map but on a smaller scale (32 miles =1 inch —the scale of the old map being 6 miles =1 inch) and with the geological formations represented by a system of lines of shading, instead of by colors. Although the map is copied with as much accuracy as was regarded practicable and desirable, I have prefixed the word "*Approximate*" to its title. It is evident that even the original map was never intended to be considered as more than an approximate representation of the areas of geological formations in the State. *An accurate geological map of the State is still a desideratum.*

In this connection I beg to make a few suggestions for some of the most important work that the State ought to undertake as a *continuation of its Geological Survey.* In part these suggestions are the same as those I had the honor to make in my report to your Excellency and the Board of Trustees of the State Museum, in January, 1889. They were also used as the substance of two bills introduced in the last Assembly of the State Legislature, but, although seemingly meeting the approval of the Legislature, were "tabled" at the third reading. I would suggest:

1. That a continued collection be made of logs of all borings, shafts, etc., in the State. Owing to the imperfect character of the records of such undertakings, as usually made, each locality where a boring or sinking of a shaft is in progress should be visited, or, at least, arrangements should be made with those in charge of the work, for the proper preservation and identification of samples of the strata.

2. That a detailed topographic, or at least hypsometric survey of the State be made on a plan conforming to similar surveys already made, either wholly or in part, by New Jersey, New York, Massachusetts, Wisconsin and Michigan, and now in progress in Pennsylvania and Minnesota.

Thus would be furnished the necessary data for elucidating many problems of the greatest economical importance to such industrial pursuits as require a correct insight into the geological structure of the State. I would therefore suggest:

3. That the facts thus obtained, and further supplemented, when necessary, by local investigations, be used as the basis of a series of either annual or biennial reports on the Geology of Illinois, with special reference to the underground topography of the different coal beds, water bearing, and other strata, showing their distribution and depth below the surface in the various parts of the State.

It is pretty well settled that our coal beds were not laid down in broad sheets of even thickness over large areas, but were formed on the low lands of the then surface, while the higher portions were left bare. The investigation, above suggested, would go far to indicate the position and extent of these barren grounds. It would also give the best guidance in determining where artesian water, oil, gas, etc., may be expected—or, at least, where they *cannot* reasonably be expected.

In connection with these investigations particular attention should be given to the quaternary deposits in the State. Much interest is being manifested in the *glacial geology* of the United States; our State ought to coöperate with her sisters by making a thorough study of her moraines and other glacial deposits. The subject is large and has hitherto received little attention. Indeed, our present knowledge of these deposits in Illinois is merely rudimentary. We know but little even about the distribution of drift clays, marls, sands, gravels, and other elements of the "drift." That treasures of incalculable value to our commerce and industries lie hidden therein, within easy reach, cannot be doubted.

Within the last few years many new facts have been brought to light in connection with the dynamics of the lead region. Wisconsin has made a very thorough survey of so much of this region as lies within her borders, and our State should supplement it by equally thorough work in the light of the new facts, on this side of the line.

I would also suggest:

4. That careful laboratory tests, physical and chemical, be made of our coals, rocks, clays, etc., to ascertain their properties and adaptability to various uses. The character of the coal from various mines and veins is continually changing; yearly analyses with regard to their fuel value should be made and published. The tests of building-stones should determine their strength and resistance to frost and heat; and their resistance to ordinary atmospheric agencies should be studied at their natural outcrops and in buildings where they have been used. The immense importation of cement from other States and from Europe, in face of the fact that we undoubtedly possess, within the limits of our own State, excellent raw material, as well as cheap fuel, for its production at home, in unlimited quantities, amply warrants a careful investigation of the possibilities of building up a cement industry in Illinois.

The State possesses many valuable deposits of fire, potter's and paint clays and of shales, whose properties have never been tested. These should be analyzed and practical tests made to ascertain their usefulness. Such tests of the clays of Ohio and New Jersey may be taken as models.

In order to increase the usefulness of the work already done by the Survey, and to adapt it to the wants of the people, I beg, finally, to suggest:

5. That the State should issue, as soon as possible, a systematic palæontology, which shall contain a brief description and, where possible, an illustration of each species found within her borders, together with its horizon or horizons and a reference to the work in which the original description may be found.

Such a work as well as *all* other reports of the State Survey, including also all maps and diagrams, should be placed on the market at actual cost by the State, and would, I am sure, meet with ready sale to students and others interested in the subjects treated in these publications.

I cannot close these remarks without expressing my obligation to Professor CHARLES W. ROLFE, of the Geological Department of the Illinois State University, at Champaign, for his valuable suggestions and frequent manifestation of interest in my work.

I have the honor to be,

Sir,

Your obedient servant,

JOSUA LINDAHL.

ILLINOIS STATE MUSEUM OF NATURAL HISTORY,
SPRINGFIELD, ILL, July 10, 1890.

PART I.

GEOLOGY OF ILLINOIS.

By A. H. WORTHEN.

CHAPTER I.

DRIFT DEPOSITS OF ILLINOIS.

In the preceding volumes of my report on the Geological Survey of Illinois, no exhaustive discussion of the character and extent of the superficial deposits of this State was attempted, because the necessary data were not attainable from an examination of the natural exposures of the formation alone.

Subsequently, in the development of our coal resources, many shafts were sunk through the superficial deposits in various portions of the State, which, with other artificial excavations, have afforded all the necessary data for a more comprehensive treatment of the subject; and some of the most instructive sections of the drift deposits obtained in this way we shall present in detail in the following pages.

These deposits consist mainly of clay, sand and gravel, which are spread unconformably over the stratified rocks, covering them to the depth of from ten to more than three hundred and fifty feet. Over large areas in the central portions of the State they extend far below the drainage level of the streams, and consequently only the upper portion of the deposit can be seen in the bluffs and banks of the water courses.

The drift deposits are important in an economical point of view: *First*—Because they determine the character and productive capacity of the soil upon which all other industries are largely dependent. Soils consist mainly of pulverized rock, to which is added such organic substances as result from the growth and decay of animal and vegetable organisms upon the surface, and the soils of Illinois, being the result of disintegration of the limestones, sandstones, shales, etc., which constitute the various palæozoic formations of the Mississippi valley, contain all the essential mineral ingredients that are required to constitute a soil of surpassing fertility.

Second—The drift deposits are also the main source of our water supply, and of those homely but indispensable products, sand, clay and gravel, which enter so largely into the industrial pursuits of the laboring classes. Every man who sinks a well, digs a cellar or a ditch, or grades a roadway, penetrates this formation, and hence it becomes the one with which the people are most frequently brought in contact, and therefore the one in which they are more directly interested than in any other of the geological formations.

In order to arrive at a satisfactory solution of the phenomena presented by the drift deposits, it will be necessary to consider, briefly, the condition that prevailed at the commencement of the period which they represent.

At the close of the carboniferous era, nearly the whole area of the State of Illinois, as well as that of the adjacent States on the north and east, was elevated above the ocean's level, beneath which it has not since been submerged. During all that vast period of time, during which the Jurassic, Cretaceous and Tertiary formations were deposited over such portions of the continent as were still beneath the ocean, nearly the entire area of Illinois was above the ocean's level, and subject to the erosive agencies that are always prevalent upon the land.

During the earlier portion of this period, the river valleys were excavated, as well as others that are now filled with drift material, the existence of which is entirely unknown and unsuspected until revealed by artificial excavations. The eroding forces of this period were not confined to the excavation of the river valleys, but they carried away a vast amount of solid rock strata, not only from the northern portion of the state, where the evidence of erosion is most apparent, but probably over nearly the whole area of the state as well.

Prof. D. J. Whitney, in his report on the lead region, in the first volume of the geology of Wisconsin, estimates the amount of solid rock strata removed by erosive agencies over the region south of the Wisconsin river, at three hundred and fifty to four hundred feet, and it is highly probable that even this estimate, large as it may seem, does not fully represent the extent of the erosion that has taken place not only in northern Illinois, but over the greater portion of its entire area.

The Niagara limestone, that caps the mounds in JoDaviess county, was no doubt continuous over the whole of that and adjacent counties, and it is also highly probable that the Hamilton shales, which now overlie the Niagara in the vicinity of Milwaukee, originally extended west so as to unite with the Devonian beds of northern Iowa, and hence the full extent of the erosion to which the northern portion of Illinois and the adjacent regions in Wisconsin and Iowa was subjected, may far exceed the estimate of Prof. Whitney, as it probably embraced all the palæozoic rocks from the top of the Devonian to the middle of the Calciferous formation inclusive.

Moreover the occurrence of Cretaceous fossils in the drift clays point to the existence of deposits of this age far beyond the known limits of this system, and it is almost certain that extensive deposits of Cretaceous strata have been swept away by erosive agencies in the region now under consideration.

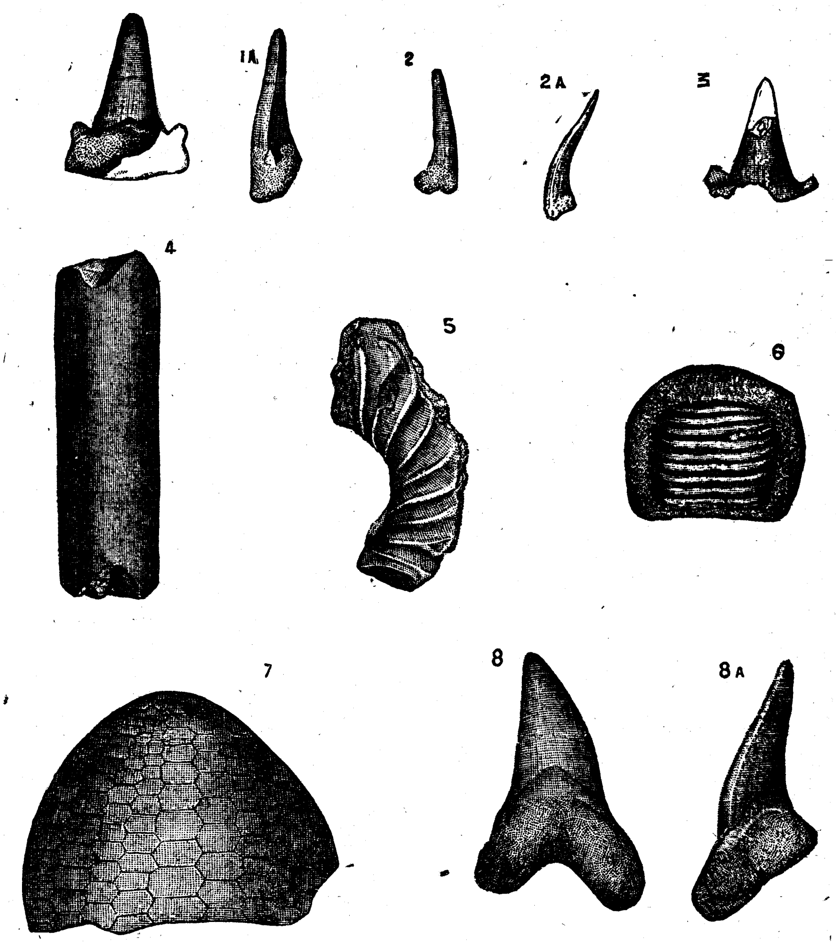
These marine organisms may be properly termed "intrusive fossils," and belong to an age far more remote than the beds of clay and sand from which they were obtained, and they seem to show conclusively that beds of Cretaceous, and possibly of Tertiary age as well, once extended over areas in the Mississippi valley, where they do not exist *in situ*, at the present time. Whether these marine strata extended generally over a large surface area, or were confined to the valleys of the main water courses, is an unsettled problem.

The specimens figured on the following page embrace three or four species of shark's teeth, fragments of an *Ammonite*, a *Belemnite* and an *Echinoid*. The last three, and the tooth of *Ptychodus*, are undoubtedly of Cretaceous age, and were found in the boulder clay far above the flood plain of the Mississippi river.

Figures 1, 2 and 3 represent forms that may belong to a later period and were found in the sands of the Mississippi valley. It seems probable that the valleys of our great rivers may have been partially filled with Tertiary deposits before the drift clays were laid down, and that the strata of this age may still form the lowest beds under the alluvial deposits of the Mississippi and other large rivers of the Northwest.

These fossils show so little of the wearing effects of transportation, as to impress one with the conviction that they were derived from strata originally deposited at a locality not very remote from the places where they were found.

The following wood cuts represent the fossils now in the author's possession, that were obtained from the drift clays of Illinois, Iowa and Missouri.



Nos. 1, 2 and 3 belong to the genus *Lamna*, a genus common to the Chalk and to the Eocene Tertiary. No. 8 belongs, apparently, to the genus *Oxyrhina*, and closely resembles *O, crassa*, Agassiz.

No. 1 was found on Skunk river, near its mouth; No. 2, in the river sand at Warsaw, Ill.; No. 3 is embedded in a nodule of hard ferruginous sandstone, and was found at the mouth of the DesMoines river; No. 8 was obtained near St. Francisville, Mo., from drift clays above the flood plain of the river.

Nos. 4, 5 and 6 were found in the blue clays of the drift at Golden Bluff Vineyards, about two miles south of Warsaw, and their Cretaceous aspect will, no doubt, be readily conceded. No. 4 is a *Belemnite*, No. 5, a fragment of an *Ammonite*, and No. 6 is a tooth of *Ptychodus polygyrus*, of Agassiz, an undoubted Cretaceous form.

No. 7, is a characteristic Cretaceous *Echinoid* belonging to the genus *Ananchytes*, and was found near Petersburg, in Menard county.

In addition to the Cretaceous fossils above mentioned, I have seen in the collection of the Hon. Wm. McAdams, of Alton, a very large shark's tooth measuring nearly three inches in length, that was found in sinking a well in the valley of the Illinois river, a few miles above the mouth of that stream, at a depth of more than twenty feet below the surface; and also the vertebra of a shark found in sinking a cistern on a sand ridge in the same county, at a depth of fifteen feet, taken out in Mr. McAdams' presence. This bone has the dark brown color characteristic of the *Ichthyic* fossils usually found in Cretaceous and Tertiary strata.

In further proof of the supposition that pre-existing Cretaceous strata were broken up and partially redeposited at local points in the Mississippi valley during the drift period, we may cite the frequent occurrence of beds of paint and potter's clays at the base of the drift deposits. These clays are generally composed of a fine silicious sediment of various colors, that are lithologically quite unlike the sediments that would result from the erosion of any of the palæozoic rocks occurring in the adjacent region.

Hence it seems highly probable, as has been suggested by Dr. White, in the Second Geological Survey of Iowa, that the Cretaceous deposits once covered a much wider area in the Mississippi valley than they now occupy.

In the report above cited, Volume 2, page 212, Dr. White sums up his conclusions as to the probable extent of the Cretaceous strata in Iowa before they were subjected to denuding forces, as follows:

"How far the Cretaceous strata which appear upon the southwestern margin of the region, extend over the remainder of it unseen beneath the surface now covered with the drift, is not now known, because no exposures of them are found there. We have, however, many reasons to believe that the last named strata once covered nearly, if not quite, the whole region, and a large part of them, being all very friable, were removed by erosion during the Tertiary age, and much more swept away by glacial action during the drift or glacial epoch, and the remainder are now mostly covered by the drift. Besides more or less indistinct indications of the correctness of this view, gathered from observations within the region itself, we find traces of Cretaceous strata at several points within the State of Minnesota, extending as far as, or farther to the eastward than the eastern border of the region under discussion. Frequent exposures of strata of Cretaceous age exist to the southward of it, and also to a point in Guthrie county as far eastward as the eastern border of this region; and, although no exposure of these strata now appear at the surface in the intermediate space, judging from the uniformity of the surface, and from our knowledge of the position that the underlying strata must necessarily assume, it is inferred that the whole intermediate region originally received deposits of Cretaceous strata continuous with those that now appear.

These Cretaceous strata everywhere, both in Minnesota and Iowa, show evidence of extensive glacial and other denudation. This has been accomplished with facility in consequence of the great softness and friability of all the strata of the age. The denudation of these strata have been so great that their remains now exist in some parts only as scattered outlines resting upon older rocks."

The facts observed in Illinois would seem to fully sustain Dr. White's views in regard to the former extent of the Cretaceous formation, and it is highly probable that the local patches of Cretaceous strata may have been deposited as far eastward as the borders of the Mississippi valley, and southward until they united with strata of the same age south of the Ohio river.

After this brief view of the conditions that probably prevailed during the earlier portion of the drift period, we may now proceed to note briefly the several subdivisions of the drift deposits. Taking them up in the descending order, they are as follows:

First—we have the alluvial deposits of the river valleys, or those below the ordinary flood plain of our large rivers. These deposits consist mainly of sand and fine silicious sediment, held in suspension by the water during periods of inundation, and were deposited over the flood plain as the waters receded to their ordinary level.

Second—We have the river terraces that were formed in a similar manner to the river bottoms, but at a time when the flood plain was from thirty to forty feet higher than at the present time. Those terraces form eligible sites for many of our river towns, among which we may mention Naples, Meredosia and Havana, on the Illinois river, and Oquawka and New Boston on the Mississippi. The terrace "epoch" is probably nearly synchronous with that of the loess.

Third—Modified drift and loess. The term modified drift is applied to beds of sand, gravel and clay that have been formed from the older members of the series by the sifting process of wave action or water currents. This deposit generally forms the upper portion of the river bluffs, and often fills lateral valleys on the main water courses.

The bluffs at Warsaw in Hancock county, presents an instructive section of modified drift and loess. These deposits are there from forty-five to fifty feet in thickness, and were cut through in grading Main street to the river landing, showing the following section:

	Ft.	In.
Ash-colored marly clay	10	
Brown clay	10	
Brown sand, stratified	8	
Blue sandy clay	2	6
Fine gravel and clay	2	6
Yellow sand	2	
Gravel and boulders	8	
Bluish clay—exposed	5	

On a ravine a short distance south of Main street, the bluish clay at the base of the above section is filled with fragments and branches of wood, and a bone, thought by its finder to be the femur of a human skeleton, was obtained from it, but unfortunately was allowed to crumble to fragments from a lack of the knowledge required to preserve such fragile specimens from destruction.

The "loess" consists of buff and gray marly sand, and usually caps the river bluffs, imparting to them the bald, knobby character so noticeable on the main water courses of the West. Its maximum thickness in Illinois probably does not exceed sixty to seventy feet, and is usually much less.

At Quincy, the loess ranges in thickness from thirty to forty feet, and is underlaid by a foot or more of chocolate colored clay and a few feet of chert and brown clay, (local drift), derived from the decomposition of the underlying Burlington limestone. The chocolate colored clay contains twigs and other vegetable remains, indicating that it was originally a surface soil, and it is probably the equivalent of the "Forest-bed" of the Ohio reports.

The loess is not restricted to the vicinity of the rivers, but is spread over wide areas in the central and southern portions of Illinois. In the vicinity of Springfield it consists of two beds, one of brown silicious clay, and the other gray marly sand, aggregating a thickness of six to eight feet.

In the western part of the county, and the adjacent portion of Menard, these beds, frequently attain an aggregate thickness of ten to fifteen feet, according to the statements of professional well-diggers, and are usually underlaid by a black, mucky soil, varying in thickness from two to three feet.

The fossils of the loess comprise nearly all common species of terrestrial, and a few species of fluviatile mollusca, and in addition to these it has afforded the largest portion of the fossil mammalia hitherto found in this State. The Hon. Wm. McAdams, who has given especial attention to the fossils of this horizon, has obtained a fine collection of mammalian remains at Alton and Chester, embracing the bones of the *Mastodon, Mammoth, Megalonyx, Bos primigenius, Castoroides* *ohioensis* and several species of rodents, some of which belong to extinct species. These discoveries seem to fix the age of the loess as not later than the close of the Pliocene.

The smaller teeth are usually found attached to, or embedded in, the calcareous nodules that abound in the loess, which are known under the popular name of "petrified potatoes." Locally these nodules assume fantastic forms, similar to the common "clay stones" that abound in the stratified clays of the Connecticut valley, and if they were of the same color, could not be readily distinguished from the New England specimens.

Fourth—The fourth division of the drift of Illinois comprises the boulder clays. These are usually yellowish at the top and bluish gray below, and contain numerous boulders mostly of small size, that are partly derived from foreign material, and partly from the bed-rock of the adjacent region. This division of the formation ranges in thickness from twenty, to more than a hundred feet, and the embedded boulders vary in size from a few inches, to two feet or more. Some of these transported masses are angular, as though they were embedded in shore ice, and then transported by water currents to the spot where they were finally dropped, while most of those of foreign material are rounded and sometimes striated, as though brought in violent contact with angular fragments of still harder material.

Trunks of large trees are sometimes met with in sinking wells through the boulder clay, but no animal remains have been authentically reported from it, to my knowledge, in this State, except the Cretaceous fossils illustrated on a preceding page. The boulder clay is frequently underlaid by a black, peaty soil, varying in thickness from two to thirteen feet, filled in many places with twigs, branches, occasionally whole trunks of trees, the wood in many cases being in a good state of preservation.

Fifth—The fifth division comprises the ancient soil above mentioned, and the underlying stratified clays and sands, which locally includes a second soil, similar in character to that immediately below the boulder clays. This division fills the ancient valleys formed by erosive agencies during the earlier portion of the drift period, and consequently is somewhat local in its development.

The drift deposits, as may be seen by the sections to be found on the following pages, attain their maximum thickness in the central portions of the State and thin out to the southward, all the beds, except the loess, disappearing before reaching the Ohio river.

Throughout the southern counties of the State, the loess, including the sandy marl and the brown clay which lies above it, with a few feet of local drift beneath it, the whole aggregating a thickness of ten to thirty feet, are the only remaining representatives of the drift deposits of Central Illinois. The local drift appears to be entirely derived from the country rock on which it rests, for where the underlying rock is limestone, the embedded fragments of the superincumbent bed will be composed of the cherty material derived therefrom. Where the underlying rock is sandstone or sandy shale, sand and nodules of sandstone will be found to constitute the main portion of the overlying deposit.

The sections that are to follow, extend over two-thirds of the entire area of the State, including the central and northern portions, where the greatest accumulation of foreign drift occurs.

In Carroll county, on the northwestern border of the State, the following section of a well in Mt. Carroll, was obtained by the Hon. James Shaw, and is given in his report on the geology of that county, as typical of the drift deposits of that region:

	Feet.
Black prairie soil	2
Yellow fine grained clay	13
Common blue clay	2
Reddish clay and gravel	15
Tough blue clay	2
Coarse stratified gravel	3
Pure yellow sand	11
Black mucky clay	5
Total	53

If there is any representative of the boulder clay in the above section, it must be the fifteen feet of clay and gravel near the middle of the section.

In the counties to the eastward of Carroll, Mr. Shaw estimates the average thickness of the drift deposits in Stephenson and Winnebago counties at about twenty-five feet, while in Ogle county he places its maximum thickness at "more than a hundred feet," and he says, "it is largely composed of coarse gravel and fine white sand. The gravel beds contain numerous boulders, some of foreign material, and some derived from the limestones of the adjacent region."

In his report on Lee county, the same author gives the following section of a well in the town of Palmyra:

	Feet.
Black mould and subsoil	6
Finely comminuted buff yellow clay	12
Blue compact laminated clay	10
Black muck full of sticks, etc.	5
Total	33

The same author says further: "Over the southern portion of the county, the drift clays are probably thicker than in the vicinity of Rock river. Where thickest, the blue clay is much the heaviest deposit, and is often underlaid by the black mud of the above section, or a bed of gravel and dirt of variable thickness."

In his report on Whiteside county, Mr. Shaw says, in speaking of the drift deposits: "At one locality, a well was sunk twelve or fifteen feet through yellow unctuous clay, then blue clay was struck, and in about fifty feet more a great quantity of sticks and wood, apparently cedar and pine, was found. The water in the well had, of course, a brackish taste. This woody deposit was about at the base of the drift."

In the survey of Kankakee and Iroquois counties, the late Prof. Frank H. Bradley found conclusive evidence of the existence of an ancient channel which he supposed to have been a western outlet for the waters of Lake Michigan, and I quote the following description of it from his report, Geol. Survey of Ill., Vol. IV, page 229, *et seq:* "The depth of this channel in its northern part is unknown; but its western bank is seen on the Kankakee, just above Momence, where the rock suddenly breaks off, and probes forced to considerable depths found no solid bottom. These facts were ascertained in 1867, by Col. James Worrall, then of the Illinois River Survey, now of Harrisburg, Pa., who also informs me that the same 'shoulder' of rock is found on the Calumet, nearly due north from Momence. In this part of its course, passing through very solid rocks, the channel is rather narrow, rock having been found upon its east side and south of the Kankakee, within seven miles of Momence; the exact location of its eastern bank is unknown. From this point the course of the channel is not certain; but it probably keeps near the State line until it nearly or quite reaches the valley of the Iroquois, then runs westerly to the valley of Spring creek, having a depth of one hundred and sixty feet near Sheldon (as reported by H. S. Wing, Esq., of Kankakee City,) and then turns south with a depth of two hundred and sixty-eight feet between Onarga and Gilman, of 'over four hundred feet' between Onarga and Spring Creek Station' and of 'over three hundred feet' between Paxton and Rantoul, as reported by John Faulds, Esq., of Catlin, Vermilion county."

"As the western bank was found at Chatsworth, Livingston county, with its top eighty-eight feet and its bottom two hundred feet below the surface, thus giving a width of fifteen miles or more, it is evident that the softer materials of the Devonian, Sub-carboniferous, and Coal Measure shales and sandstones have afforded less resistance to the denuding agent than the solid Silurian limestones which confined it to less than seven miles at Momence. Champaign and Urbana, in Champaign county, are located over this old channel, and from one hundred and seventy-five to two hundred and twenty-five feet above its floor, but are probably near its eastern border. Here and at Chatsworth we find, among the drift-beds, a single layer of old mucky soil, with leaves and trunks of trees. At Bloomington, in McLean county, the channel is two hundred and fifty feet deep, and the beds which fill it include two beds of old soil, which I am inclined to accept as indications that this point is near the middle of the old valley, or at least near its principal channel."

Dr. Bannister, in his report on the northwestern counties of the State, gives no artificial sections of the drift, but he gives the following as an approximate section of this deposit in the bluffs of Lake Michigan, near Lake Forest:

	Ft.	In.
Clay	10 to 14	
Sand and clay intermingled	9 to 12	
Clay	1 to 1	6
Sand	1	
Clay	50	
Maximum	78	6

In regard to the boulders scattered through the drift clays of this region, Dr. Bannister says: "Most of the large boulders in this vicinity are of limestone; the masses of the primary or intrusive rocks are generally of comparatively small size, or when of considerable size are but rarely met with."

So much must suffice our present purpose to illustrate the prevailing character of the drift in the extreme northern portion of the State, where we might expect to encounter the most unmistakable evidence of glacial action, if these superficial deposits were really due to the action of land ice.

Coming south, within the northern boundary of the coal field, we find an increased thickness of the drift deposits, and the numerous artificial excavations that penetrate entirely through them, afford the most satisfactory evidence of their general character and extent.

In sinking the coal shaft at Wenona, in Marshall county, the following drift beds were encountered:

	Feet.
Soil and yellow clay	10
Blue clay (boulder clay)	46
Sand	10
Hard-pan	34
Red clay	3
Total	103

The red clay at the base of the drift at this locality was probably derived from the shales of the coal measures on which it rests.

At the gas well near Clinton, in DeWitt county, the following beds of drift were encountered without quite reaching the bed rock:

	Feet.
Soil and yellow clay	15
Hard blue clay (boulder clay)	30
Black mould with wood	2
Dry drab colored clay	8
Drift-wood and black mould	8
Drab colored clay	16
Drift-wood, etc	2
Drab colored clay	26
Hard-pan	12
Drab colored clay	4
Green copperas colored clay	10
Total	133

Dry sand and pebbles were thrown out upon the surface by the pressure of the gas, indicating the presence of sand and gravel beds beneath the green clay, the gravel beneath and the clay above furnishing the necessary conditions for the reception and retention of the gas, which was probably generated in the bituminous shales of the coal measures beneath.

The well at the railroad station at Odell, in Livingston county, passed through the following beds, according to the record as reported, without reaching bed rock:

	Ft.	In.
Soil and yellow clay	9	
Blue clay (boulder clay)	66	
Gravel and sand	5	
Blue clay	15	
Gravel and sand	2	
Blue clay	8	
Gravel		4
Blue clay	22	8
Gravel		4
Blue clay	2	
Total	130	4

The coal shaft at Bloomington, in McLean county, was carried down through the thickest deposit of superficial material penetrated by any coal shaft in this State. This extraordinary thickness of drift fills the old channel, already mentioned, by which the waters of the great lakes found an outlet into the valley of the Illinois river, and thence, through the valley of the Mississippi, into the Gulf of Mexico. The following is a copy of the record of the superficial material in this shaft:

	Feet.
Soil and brown clay	10
Blue clay	40
Gravelly hard pan (boulder bed)	60
Black mucky soil	13
Clay hard-pan	89
Black soil	6
Blue clay	34
Quicksand	2
Total	254

The wood found in the mucky soil at the depth of one hundred and ten feet proved to be in a remarkably fine state of preservation, and belonged apparently to a species of cedar. The quicksand at the bottom of the above section contained the comminuted fragments of terrestrial and fluviatile mollusca, of which only one specimen was obtained in a condition to be determined. This specimen was submitted to the late Dr. Stimpson, of Chicago, for examination, and was by him decided to be a *Helicina occulta*.

One of the first attempts to shaft for coal in this State was made at Coatsburg, in Adams county, and this shaft afforded the first evidence obtained of the existence of a bed of soil beneath the boulder clay. The following is a copy of the record of this shaft:

	Ft.	In.
Soil and yellow clay	6	
Clay with gravel and boulders	85	
Black soil	2	6
Stratified clay	6	
Tough blue clay	20	
Total	119	6

This shaft was located on the high prairie that forms the divide between the Illinois and Mississippi rivers.

At Decatur, in Macon county, two beds of soil were passed through in sinking the coal shaft at that point, and the following is a copy of their record as published by the local press:

	Ft.	In.
Soil and clay	31	
Sand, with two clay bands	11	
Quicksand	2	6
Tough clay	4	
Black soil	2	6
Sand	2	
Clay	3	
Greenish sand	6	
Gravelly hard-pan	11	
Black soil	2	
Quicksand	4	
Gravelly clay	24	
Quicksand	6	6
Total	109	6

At Pana, in Christian county, about thirty miles south of Decatur, the two ancient soils of the above section were also encountered in their shaft as is shown by the following record:

Soil and clay	11	
Blue clay	4	
Sand and gravel	12	
Hard red clay	18	
Black soil	3	6
Blue clay	57	
Black soil	2	6
Blue clay	19	
Total	127	

The following average section of the drift deposits in the western part of Sangamon and eastern portion of the adjacent county of Menard, was furnished by Mr. Joseph Mitchell, a professional well-digger, and probably fairly represents the general character of the drift in Central Illinois where no unusual amount of erosion had taken place. This section, however, does not represent the full thickness of the drift, as the wells were not continued quite down to the bed rock:

		Ft.	In.
No. 1.	Soil and yellowish subsoil	5 to 10	
No. 2.	Gray sandy clay (loess)	6 to 8	
No. 3.	Mucky clay with wood, etc	2	6
No. 4.	Bluish boulder clay	10 to 15	
No. 5.	Soft blue clay	20 to 40	
	Maximum	75	6

No. 3 of the foregoing section is not identical with either of the old soils found at Bloomington, Decatur or Pana, but it probably holds the same stratigraphical position as the "Forest bed" of the Ohio reports, and the chocolate-colored clay beneath the loess at Quincy.

At Virginia, in Cass county, however, one of the older soils was found, as shown by the following record of the shaft at that locality:

	Ft.	In.
Soil and brown clay	9	6
Blue clay and hard-pan	57	6
Black soil	3	
Hard-pan	46	
Total	116	

At the Palmer shaft, in Christian county, the following record was preserved of the drift beds passed through:

	Feet.
Soil and yellowish clay	16
Hard boulder clay	22
Soft brown clay	7
Sand	10
Gravel	1
Boulder clay	4
Total	60

Two boulder beds are reported in the foregoing section, the first immediately below the yellow clay of the sub-soil, where it is usually found, and the other at the bottom of the drift, and directly above the bed rock. Nothing is said in the record in regard to the size or number of the boulders contained in either bed, but, if we may form any conclusion from the character of the fundamental bed of the drift deposits at all the other localities given, we should be led to suspect that the lower bed here might be more accurately described as a bed of gravelly clay, rather than a bed containing boulders of any considerable size.

The record of the coal shaft at Sidney, in Champaign county, shows the following beds of drift occurring at that point:

	Feet.
Sand and yellow clay	17
Boulder clay	18
Gray hard-pan	5
Yellow hard-pan	15
Coarse sand and gravel	5
Hard-pan	35
Total	95

In a boring with the diamond drill at Tuscola, in Douglas county, the following divisions of drift material were encountered:

	Feet.
Surface soil and yellow clay	20
Blue clay	5
Hard-pan	6
Blue clay	10
Hard-pan	7
Blue clay	9
Brown clay	5
Yellow clay	8
Blue clay	6
Blue and yellow clays	31
Blue clay	22
Gravelly blue clay	30
Blue clay	13
Sand	6
Total	178

In sinking the coal shaft at Sandoval, on the O. & M. railroad, in Marion county, the following beds of drift material were passed through according to their published record:

	Ft.	In.
Soil and yellow clay	11	
Sandy clay	4	6
Blue clay and gravel	20	
Blue clay	78	
Black soil	2	6
Blue sandy clay	6	
Quicksand	6	
Cemented gravel	1	
Total	129	

The bed of cemented gravel at the bottom of this section may be a bed of ferruginous conglomerate belonging to the coal measures, as such a bed is frequently encountered in the upper part of that formation.

At Odin, four miles east of Sandoval, a similar bed of black soil was encountered near the base of the drift, but no detailed record of the overlying beds was preserved.

South of the O. & M. railroad the drift deposits diminish in thickness, and the following section, obtained from a boring for coal at Lementon, in St. Clair county, will afford a general idea of their average thickness and diversified character in Southern Illinois:

	Feet.
Soil	3
Yellow clay	14
Sand and gravel	1
Blue clay	20
Blue clay (soil?)	1
Blue and yellow clays	11
Red and yellow sand	1
Total	51

The foregoing sections afford a fair exhibit of the superficial deposits of this State, all of which may be included in the general term drift. They cover more than two-thirds of its entire area, including the central and northern portions of the State, where these deposits attain their greatest development.

In the southern portion of the State, for a distance of fifty to seventy-five miles north of the Ohio river, foreign material is comparatively rare, and often absent altogether, and when found the boulders are of small size, seldom exceeding a few inches in diameter.

Specimens of native copper have been found in this portion of the State, but their presence there may be due to human agencies, as it is well known that copper was an article of commerce among the primeval races of the Mississippi valley.

The conditions under which the drift deposits were accumulated, and the agencies employed in their deposition, are still unsettled questions, and the complex character of the phenomena presented affords a wide field for speculation.

It has been generally conceded that a colder climate than that of the present time prevailed over the northern temperate zone when the boulder clays were deposited, and that ice was an important factor in the transportation of the foreign material contained therein.

Two rival theories, known respectively as the "glacial" and the "ice berg" theories, have been advanced to explain the origin of the drift, both of which have found able advocates to urge their respective claims. The latter theory attributes the accumulation of the drift and the foreign materials occurring therein to floating ice and water currents during a period of submergence, when the entire surface over which the drift extends was beneath the water.

The "glacial theory," on the other hand, attributes the accumulation of the boulder clays to the action of land ice, and is based upon the assumed conditions of an arctic climate, and a vast continental "glacier" or "ice cap," that was supposed to have covered all the North American continent north of the fortieth parallel of latitude.

Prof. Dana, in his Manual of Geology, 2d ed., page 544, gives the following as the conditions supposed to prevail over the northern portion of the continent during the "glacial period":

"During a glacial epoch of the kind here supposed, the whole northern portion of the continent down to the southern limit of the Drift, would have been covered by a vast and almost uninterrupted glacier. This is now the case in North America with the return of nearly every winter. But the depth, instead of being as now, but a few feet, and that mostly of snow, must have been, judging from the height on the hills to which the striæ extend, at least 4,000 to 5,000 feet, and the material, as in all such thick accumulations, would have been ice, and above this there may have been other hundreds of feet of snow. Glaciers of so vast extent and thickness, would have moved downward wherever the conditions would permit, like the glaciers of the Alps, and all the more readily for their enormous weight."

A glacier is usually defined as "an immense mass of ice, or snow and ice, moving slowly down mountain slopes or valleys," and it is probable that the earliest advocates of glacial theory in this country formed their conclusions mainly from an examination of the phenomena presented in New England, and other mountainous regions, where the conditions necessary for the formation of typical glaciers were prevalent, but as such conditions were not found in the broad plains of the northwest, the "ice sheet" or "ice cap" was substituted for the glacier, to explain the occurrence of foreign material in the drift deposits of the northwest.

The glacial theory requires for its support, a supposititious elevation of the surface, to the extent of several thousand feet, of all that portion of the continent over which the drift is distributed. This was necessary in order to obtain the conditions of an arctic climate in a temperate zone, a supposition with no evidence to sustain it except what is afforded by the so-called glacial phenomena.

As has been clearly shown by the preceding sections of the drift deposits of Illinois, the boulder clays invariably overlie an old soil, which covers such a wide area as to justify the conclusion that it was originally spread over the whole surface of the State, and it seems highly improbable that a vast ice sheet, of enormous thickness, could push its way over a nearly level surface, and leave the soil intact beneath. Moreover, wherever a good section of the drift clays, overlying the black soil, is well exposed, the evidences of a more or less distinct stratification is observable, a fact which does not accord with the "glacial theory," but indicates clearly that water was an active agent in their accumulation.

Foreign boulders are comparatively rare in the central portion of the State, except in the vicinity of the old valleys, where they are more abundant than elsewhere, though seldom exceeding a diameter of two feet, and in the extreme southern portion of the State, those exceeding a few inches in diameter are seldom found. This is precisely what we might anticipate if they were transported by floating ice, whereas if their occurrence was due to the southward movement of land ice, they should be equally or more abundant at the southern extremity of the ice sheet than elsewhere.

Dr. Drake, of Cincinnati, in an essay published in the Transactions of the American Philosophical Society, in 1825, advanced the theory "that the boulders of foreign material in Ohio, with the clays in which they were imbedded, were brought from the north by floating ice during a period of submergence;" and Sir Charles Lyell, on his first visit to America, adopted a similar view, and explained the drift phenomena observed by him in Canada, as the probable result of floating ice, loaded with the rocks and detritus of the north.

Prof. Dawson, of McGill College, in his Acadian Geology, advocates a similar theory in explanation of the drift phenomena observed by him in Nova Scotia. In discussing the probable origin of the drift, on page 64 of the volume above cited, the author says: "Let us suppose then, the surface of the land, while its projecting rocks were still uncovered by surface deposits, exposed for many successive centuries to the action of alternate frosts and thaws, the whole of the untraveled drift might have been accumulated on its surface. Let it then be submerged until its hill-tops should become islands, or reefs of rocks, in a sea loaded in winter and spring with drift ice, floated along by currents which, like the present Arctic current, would set from N. E. to S. W., with various modifications, produced by local causes. We have in these causes ample means for accounting for the whole of the appearances, including the traveled blocks, and the scratched and polished surfaces."

The enormous transporting power of floating ice is well known to be fully adequate to explain the occurrences of boulders, and any other foreign material occurring in the drift deposits, and the low temperature prevailing in the high northern latitudes, from which the foreign material in the drift of the Mississippi valley has come, furnishes the essential conditions for the breaking up of solid rocks, reducing the broken masses to the condition of boulders, and transporting and distributing them as far as the drift deposits extend.

The scratching and polishing of the hard rock surfaces beneath the drift, as well as the striation of some of the boulders, may be readily explained by floating ice, with embedded angular fragments of still harder material, that would act as gravers upon whatever solid substances with which they were brought in contact.

The "iceberg" theory requires the assumption of no extraordinary conditions to explain the drift phenomena, and it is a generally accepted principle in geological science that no resort to extraordinary suppositions is justifiable, where phenomena can be explained by the operation of well known causes.

The gradual change of level in the relations of land and water, is a dynamical fact universally admitted, and a general submergence of the surface after the disappearance of the continental glacier, or ice sheet, is admitted by the advocates of the glacial theory; and, if the date of this submergence should be carried back to the period immediately following the formation of the ancient surface soil, beneath the boulder drift, we obtain the essential conditions required for the accumulation of the succeeding deposits of the drift period.

From the facts presented in the foregoing pages, we may assume that the drift period represents a vast epoch in geological time, during which a considerable portion of the Mesozoic formations were in process of deposition over such areas as were still submerged beneath the ocean; and hence the term Post Pliocene can only be applied to the latest formed of these deposits, the loess, which contains the oldest fossil mammalia hitherto found in the superficial deposits of Illinois.

The succession of events transpiring in the northwestern portion of the United States during the drift epoch, we may assume to be somewhat as follows: First, the gradual elevation of the surface above the ocean level at the close of the carboniferous period, followed by the extensive denudation of the palæozoic rocks, and the excavation of extensive valleys, which seems to have been the prevailing condition in the region now under consideration during the Triassic and Jurassic periods.

The next occurrence in the order of succeeding events was the partial filling of the valleys with clay, sand and gravel, and the formation of the lowest bed of ancient soil beneath the boulder clay. This was followed by a partial or entire submergence of the surface, and the accumulation of the sands, clays, etc., that underlie the soil which occurs immediately beneath the boulder clays.

Then the surface was elevated and the marshy swamp soil under these clays was formed. A second submergence then followed and through the agencies of water currents and ice-floes, the boulder clays were deposited.

This was followed by a partial elevation of the surface and the prevalence of lacustrine conditions, resulting in the deposit of the loess, while the adjacent dry land was inhabited by now extinct forms of mammalia, associated with some of those still existing in the same region. This was followed by the final emergence of the whole area, and the commencement of the existing order of things.

The mammoth and mastodon were certainly coëval with species of mammalia still existing in the Mississippi valley. This fact has been clearly established by the collection of fossils made by Mr. McAdams from the loess, and by the fossil bones found between Illiopolis and Niantic, near the east line of Sangamon county. At this locality beneath a black mucky surface soil only four feet in depth, the remains of a mastodon consisting of the jaws with the teeth intact, both tusks, and several of the large bones were found associated with bones of the buffalo, elk and deer, all embedded together in a bed of quicksand that had probably once formed the bottom of a pool of water to which these animals resorted, and in which they perished. The writer was present during the disinterment of these remains, and some of the small bones of the mastodon and all those of the smaller animals except the antlers of the elk are now preserved in the cases of the State Museum of Natural History.

No well authenticated discovery of the remains of mammalia in this State in beds older than the loess or modified drift, has come to the knowledge of the writer, and in every case where such finds have been reported, investigation has shown that they were obtained from beds more recent than the boulder clays. Isolated bones and teeth are often obtained from the alluvial banks of the streams, but more frequently they occur in the black peaty soil or subsoil of the marshes, in which they seem to be better preserved than when buried elsewhere.

In the early part of our investigations in Illinois and Iowa, the writer was inclined to accept the "glacial theory," as a probable explanation of the conditions under which the boulder clays were deposited, mainly in deference to the ability of its able advocates, but later and more widely extended observation have compelled its rejection as a reasonable or necessary explanation of the phenomena presented, after a careful study of the superficial deposits of this State.

When the advocates of the "ice cap" theory are able to present some tangible evidence of the former elevation of the northern portion of the American continent to the height of several thousand feet above its present level, independent of drift phenomena, or can point to some other plausible fact going to show the prevalence of arctic conditions at a former period over the temperate regions of North America, that theory may be generally accepted, but until then, it is but fair to assume that diverse opinions will prevail in regard to the agencies by which the drift deposits of the Mississippi valley were deposited.

It has seemed probable to the writer that many of the advocates of the "ice cap" theory became converts to the theory before commencing field investigation, and their researches were consequently devoted to obtaining such facts as were believed to have a favorable bearing upon the accepted theory. If they have gone into the investigation of the drift phenomena of the Mississippi valley entirely free from all preconceived ideas as to its origin, it is a question whether either "glaciers" or an "ice cap" would have been suggested as the most probable theory to explain the phenomena of the drift, as it is distributed over the vast plains of the northwest.

CHAPTER II.

ECONOMICAL GEOLOGY.

COAL.

Since the publication of Vol. VII, of these reports, numerous experiments have been made for the development of our coal resources, the great majority of which have proved successful. Among the most notable failures were those made at Tuscola in Douglas, and Sidney in Champaign counties.

Tuscola is situated some forty miles or more within the eastern border of the coal field, and also within the region supposed to be underlaid by the upper coal measures, but, a boring made there with the diamond drill to the depth of 792 feet, failed to reveal the presence of coal, or any clearly defined strata belonging to the coal measures.

The drift deposits were found to be 186 feet thick at the point where the boring was made, and if beds belonging to the coal measures were originally deposited there, they were removed by erosion at the commencement of the drift period, and the first layers of bed-rock encountered by the drill appeared to be of Lower Carboniferous age. At the depth of 645 feet a white crystalline limestone containing *Favosites* was encountered, which undoubtedly belongs to the Devonian or Upper Silurian formations.

The oblique fracture of the core taken from this boring, showed that the limestones passed through, dip at an angle of about 20°, which would give an exaggerated thickness to the beds as reported, and shows that this boring is on, or very near the center of the great anticlinal axis, which crosses northern Illinois diagonally through the counties of Ogle and LaSalle, but is hidden in its southeastern extension by the superincumbent deposits of drift material. The following is a copy of the record of this boring:

		Ft.	In.
1.	Superficial deposits	186	
2.	Sandy shale	7	
3.	Sandstone	14	
4.	Green shale	20	7
5.	Hard rock	4	
6.	Sandstone	46	1
7.	Conglomerate	6	6
8.	Sandstone with blue bands	14	
9.	Shale	118	1
10.	Soapstone (clay shale)	15	
11.	Sandstone	20	
12.	Sandy shale	10	
13.	Clay shale	42	6
14.	Hard rock	6	
15.	Clay shale	9	
16.	Slate and shale	101	6
17.	Black shale	12	6
18.	Limestone	140	
19.	White sandstone	20	
	Total depth	792	9

There is probably a considerable area along the line of the above mentioned axis extending through the counties of Livingston, Ford, Champaign and Douglas, that is colored as coal measures on the map, where no valuable deposit of coal will be found, such deposits having been removed by erosion if they formerly existed over this axis as seems probable, but the boundaries and extent of this barren area, can only be determined by the drill, or artificial excavations, as there are no natural outcrops that will help to define its extent. There are hundreds of square miles in this portion of the state, where there are no natural exposures of the bed rock, and consequently no definite knowledge in regard to the character of the underlying formations can be obtained by surface explorations, the banks of the water courses revealing nothing but the upper portion of the drift deposits.

Sidney in Champaign county, is about fifteen miles north, and twelve miles east of Tuscola, and is probably on the eastern side of the axis. In the published record of the boring there, four coal seams were reported in a total depth of 256 feet, the lower seam six feet in thickness, and the others ten, twenty and twelve inches respectively. This boring was made with an ordinary drill, and on sinking a shaft it was found that the six foot seam of coal reported in the boring, proved to be mainly a bituminous shale.

If the Diamond drill had been used the expense of sinking a shaft might have been avoided. The following record of this boring was furnished and sworn to by Mr. E. Robbins, the contractor in charge of the work:

	Ft.	In.
1. Soil	2	
2. Yellow clay	15	
3. Blue clay	18	
4. Gray hardpan	5	
5. Yellow hardpan	15	
6. Coarse sand and gravel	5	
7. Hardpan	35	
8. Clay shale	17	
9. Coal	0	10
10. Clay shale	27	
11. Coal	1	8
12. Shale	85	6
13. Coal	1	
14. Limestone	16	
15. Sandstone	4	
16. Hard shale	2	
17. Coal	6	
Total depth	256	

At Urbana and Champaign, borings have been made for coal and favorable results reported, but all attemps to carry a shaft down through the water-bearing sand and gravel beds of the drift, have hitherto been unsuccessful.

The following beds of drift were encountered in attempting to sink a coal shaft at Champaign, the details of which were published in the report of Prof. Frank H. Bradley on the geology of this county in Vol. IV, page 272 of these reports.

	Feet.
1. Soil, clay and quicksand	17
2. Red and blue clay	73
3. Peaty soil	2
4. Quicksand	9
5. Soft yellow clay	9
6. Sand	3
7. Yellow clay	7
8. Quicksand and gravel	59
Total	179

In discussing the character of the drift deposits of this county Prof. Bradley says: "The purity of the white water-bearing quicksand which underlies the drift calls to mind the character of the St. Peters sandstone at its outcrop in LaSalle county, in which region it supplies several large artesian wells. The southern continuation of the anticlinal axis which brings this rock to the surface at that point, would pass not far from Champaign; and it is altogether probable that the aforesaid quicksand is really a part of the disintegrated outcrop of that bed distributed over the bottom of the ancient channel* which must have exposed it at some point in this region."

How far south this axis extends is a point as yet undetermined, and its effect upon the productive coal measures in the counties lying to the southeast of Douglas can only be determined by the drill, or the more expensive method of shafting. If it extends to the Wabash river it would cross that stream in the vicinity of Vincennes.

The record of the following borings in Livingston county were furnished by D. R. Morgan, Esq., of Strawn.

Boring at the lumber yard in Strawn by H. Clarke.

No.		Ft.	In.
1.	Soil	3	
2.	Gravel	1	
3.	Yellow clay	3	
4.	Blue clay	17	
5.	Sand and gravel with water	10	
6.	Light brown clay	20	
7.	Hard pan	2	
8.	Coarse gravel	8	
9.	Brown clay	14	
10.	Blue clay	9	6
11.	Sandstone	8	
12.	Clay shale	13	
13.	Coal	2	6
14.	Fire clay	3	6
	Total depth	114	6

Another boring near the section house west of the creek gave the following result:

No.		Ft.	In.
1.	Soil	3	
2.	Gravel	2	

* For further remarks on this ancient channel the reader is referred to the preceding chapter, page 11, and also to page 273 of vol. iv, of these reports.

No.		Ft.	In.
3.	Yellow clay	7	
4.	Gravel with water	2	
5.	Blue clay	7	6
6.	Brown clay	17	
7.	Sand with water	3	6
8.	Brown clay	8	
9.	Coarse gravel	2	
10.	Brown clay and sand	8	
11.	Sandstone and clay	4	
12.	Limestone (boulder)	0	3
13.	Hard brown clay	12	
14.	Soft blue clay	2	
15.	Hard blue clay shale	25	
16.	Sandstone and shale	11	
17.	Dark clay shale	8	
18.	Coal	2	9
19.	Fire clay	2	3
20.	Clay shale	2	
	Total depth	129	3

A boring at Cullom near the eastern line of the county made by Mr. Bennett Reeder for the Livingston county Coal Prospecting Company gave the following result:

No.		Ft.	In.
1.	Soil	1	6
2.	Yellow clay	8	
3.	Blue clay	32	6
4.	Sand	1	
5.	Blue clay	24	
6.	Solid gray silt	12	
7.	Blue hard pan	4	
8.	Sand	0	3
9.	Blue hardpan	4	9
10.	Brown hardpan	6	
11.	Sand	0	6
12.	Brown hardpan	2	
13.	Hardpan and silt	2	
14.	Sand	0	6
15.	Hard silt	3	6
16.	Hardpan	5	
17.	Clay	0	6
18.	Hardpan	3	
19.	Hardpan and gravel	2	
20.	Brown hardpan very hard	53	
21.	Red clay	5	
22.	Clay shale	19	
23.	Coal	3	11
24.	Fire clay	4	
	Total depth	197	11

The boring at Strawn in the south eastern part of the county failed to find a workable seam of coal, as shown by the following copy of the record. The boring was made by Mr. Bennett Reeder:

No.		Ft.	In.
1.	Soil	2	
2.	Sand and clay	6	
3.	Gray hardpan	2	
4.	Blue hardpan	9	
5.	Sand	0	8
6.	Blue hardpan	17	10
7.	Sand and gravel with water	7	6
8.	Blue hardpan	17	
9.	Brown hardpan	16	
10.	Sand and gravel	1	
11.	Brown hardpan	3	
12.	Sandy shale and sandstone	23	
13.	Clay shale	12	
14.	Sandy shale	6	
15.	Pink shale	29	
16.	Blue shale	10	
17.	Sandstone hard and soft	17	
18.	Clay shale with iron pyrites	8	
19.	Sandy shale	20	
20.	Dark clay shale	44	7
21.	Coal	1	2
22.	Bluish gray clay shale	7	
23.	Reddish brown clay shale	5	
24.	Sandstone	23	3
25.	Sandy shale	12	
26.	Bluish gray clay shale	2	
	Total depth	302	

The boring at Saunemin in 1882 opposite the hotel, was not carried deep enough to reach the workable coal, which at that point is 373 feet below the surface, while the boring was only carried to the depth of 250 feet. There is probably but one workable coal in the eastern portion of the county, which is No. 2 of the general section. It is the equivalent of the lowest seam in the shafts in LaSalle county, and is the one mainly worked in Grundy county, and the southwestern portion of Will and the northwestern township in Kankakee counties.

A boring made at Forest since the foregoing pages were written, the details of which were furnished by Carmon Bros., found a coal seam, probably No. 2 of the general section, at a depth of about 214 feet below the surface. The following details were furnished by the parties above named:

	Ft.	In.
Drifts clays, etc	110	
Sandstone (boulder?)	1	
Coal	0	10
Shale	3	6
Coal	0	10
Clay shale	98	
Bituminous shale	0	6
Coal	3	2
Total depth	217	10

A boring made in Livingston county by Mr. B. Reeder, at Saunemin reached a three foot six inch coal seam, probably No. 2 of the general section, at a depth of 373 feet, 3 inches.

The following record of the Saunemin boring was furnished by the Hon. Charles Ridgely of Springfield:

No.		Ft.	In.
1.	Black soil	1	6
2.	Yellow clay	10	6
3.	Blue clay	4	
4.	Sand and gravel	3	
5.	Blue clay	14	
6.	Sand	2	
7.	Blue clay	9	
8.	Gravelly clay	2	
9.	Blue clay	54	6
10.	Sand	4	
11.	Blue hardpan	28	6
12.	Brown hardpan	3	
13.	Blue hardpan	26	
14.	Sandstone	13	6
15.	Sandy clay	9	
16.	Sand and gravel with water	1	
17.	Clay shale	54	6
18.	Alternating sandy and clay shales	6	
19.	Clay shale	2	
20.	Coal slate	1	6
21.	Fire clay	2	
22.	Clay shale	78	6
23.	Alternations of sandy and clay shales	6	
24.	Sandy shale	8	
25.	Clay shale	2	
26.	Limestone	3	
27.	Sandy shale	3	6
28.	Hard standstone	1	3
29.	Sandy shale	3	
30.	Clay shale	13	
31.	Coal, No. 2	3	6
	Total depth	373	3

If Nos. 15 and 16 of this boring are sand, clay and gravel, as reported, underlying sandstone, it must be located on the border of one of the ancient valleys which are by no means uncommon beneath the drift, and the sandstone, No. 14, formed a projecting ledge, from beneath which the strata had been removed by the denuding agencies of the drift period, and replaced by drift deposits. The drift is here one hundred and sixty feet in thickness, and forms twelve distinct beds between the surface soil and the sandstone.

The thickness of the coal and the character of the roof, leads to the conclusion that the coal found here is No. 2 of the general section, which is the lowest workable bed developed on the north-eastern borders of the coal area.

Mr. T. S. Cummins of Gardner, who has been engaged in prospecting for coal in the northeastern portion of the Illinois coal field, has very kindly furnished me with the following short account as the result of his observations in that portion of the coal area:

"GARDNER, ILL., Jan. 12, 1885.

Prof. A. H. Worthen:

"DEAR SIR:—I have read with interest your Economical Geology of the State, especially that part of it relating to the county in which I reside, and where it has been my privilege to do a great deal of prospecting for coal, and boring for water, from which I have gleaned facts which may be of use to you in determining where the seam of coal in the Wilson shaft belongs, which I believe to be identical with that found on the lower Au Sable in Sec. 19. The principal characteristic of this seam is its black shale covering. It overlies the main seam, and is separated from it by sandstone and argillaceous shales aggregating 70 to 80 feet in thickness, except near the outcrop to the north and east, where the rocks between get thinner, and the seams of coal come closer together. I have bored through both seams south and west of the Wilson shaft, in South Grove township, Livingston county, on the farms of Messrs. Clover, Eldred and Pratt. The drift in that neighborhood was about 100 feet, then four feet of black slate, then the coal about 2 feet 6 inches. The other seam is 75 feet lower and 3 feet thick. I have traced it from this point to within a half mile of Braceville, where it is found in a well south of the old Augustine shaft at a depth of 48 feet. I also found it on the south line of

Braceville township, sec. 35. I found only 14 inches af coal at this point at a depth of 65 feet. At the same point we got 3 feet 4 inches of coal at a depth of 146 feet. On sec. 19 in Essex township, Kankakee county, north and east of the Wilson shaft, the upper seam is found at a depth between forty and fifty feet. This is its eastern boundary, and as the strata rise rapidly to the eastward, both seams crop out within a short distance from each other. The upper seam is best developed on sections 13, 24 and 25 in Greenfield township. On sec. 25, and on the farm of Mr. Savage a little southwest of the Wilson shaft, the depth is 106 feet; at the shaft on sec. 24, 80 feet; on 13 near the center, 80 feet, and north about 80 rods from the east line of the township, 69 feet, and on sec. 12 only between 40 and 50 feet. I have found it as far north as sec. 4, Felix township, and the main seam below it, and so you will see that although it is not a general deposit, it is distinct from the main coal and belongs above it, as I have demonstrated.

Hoping this information may be of some use to you, I remain,

Respectfully yours,

T. S. Cummins."

The upper coal described by Mr. Cummins, is no doubt identical with that which outcrops on Waupecan creek in Grundy county, and was referred to No. 3 of the Illinois section. Owing to the irregularity in the development of coal seams on the northern and northeastern borders of the coal field, the exact position to which this seam should be assigned is somewhat problematical, and it may represent a higher coal than No. 3, and the character of its roof and its distance from the lower seam, which evidently increases away from the border of the field, render its identity with coal No. 5 of the LaSalle section not improbable.

The boring at Clinton, made with the diamond drill, probably penetrated to the base of the coal measures, and passed through 352 feet of drift, showing that Clinton is located above one of the ancient valleys, by which the surface of the state was intersected anterior to the accumulation of drift material. The following is a detailed copy of the record of this boring:

No.		Ft.
1.	Surface soil	5
2.	Quicksand	15
3.	Sand with gravel and boulders	17
4.	Sand and clay mixed	53
5.	Hardpan	12
6.	Gravel	1
7.	Hardpan	4
8.	Clay and sand	4
9.	Gravel and clay	7
10.	Hardpan	3
11.	Clay and sand	7
12.	Clay and gravel	14
13.	Clay	4
14.	Hardpan	6
15.	Clay and gravel	8
16.	Quicksand	5
17.	Sand and gravel	2
18.	Coarse gravel	2
19.	Clay	6
20.	Gravelly hardpan	25
21.	Quicksand	6
22.	Sand and clay	7
23.	Gravel	9
24.	Sand	11
25.	Gravel	9
26.	Sand	9
27.	Quicksand and gravel	101
	Total depth of drift	352

This is probably the same valley described in the foregoing chapter, which was traced by Prof. Bradley into Champaign county from whence its course was apparently west through DeWitt, and thence northwardly through McLean county where it was again penetrated in the Bloomington coal shafts.

The following strata of coal measure rocks were passed through in the Clinton boring.

No.		Ft.	In.
1.	Black slate	1	
2.	Fire clay	3	
3.	Limestone	19	
4.	Fire clay	1	
5.	Gray shale	1	
6.	Red and gray shale	10	
7.	Gray shale	2	
8.	Sandstone	36	
9.	Gray sha'e	32	
	Dark shale	6	
10.	Gray shale	5	
11.	Coal	2	9
12.	Coal and slate	0	9

		Ft.	In.
13.	Fire clay	7	3
14.	Limestone	22	
15.	Sandstone	6	
16.	Gray clay shale	11	
17.	Sandstone	11	
18.	Gray shale	8	
19.	Black slate and coal	3	
20.	Limestone	7	
21.	Sandstone	19	
22.	Gray shale	10	
23.	Black slate	3	
24.	Black slate and coal	4	
25.	Gray shale	15	
26.	Sandstone	50	
27.	Gray shale	14	
28.	Black slate	2	
29.	Gray shale	5	
30.	Sandstone	23	
31.	Gray shale	21	
32.	Black slate	3	
33.	Coal	1	
34.	Black slate and trace of coal	2	
35.	Gray clay shale	3	
36.	Coal	1	
37.	Black slate and trace of coal	3	
38.	Gray shale	16	
39.	Hard impure limestone	1	
40.	Hard sandstone	3	
41.	Gray shale	5	
42.	Black slate	8	
43.	Sandstone	10	
44.	Gray shale	3	
45.	Black slate	2	
46.	Gray shale	8	
47.	Sandy shale	11	
48.	Gray shale	9	
49.	Hard limestone	1	
50.	Hard sandstone	2	
51.	Dark shale	3	
52.	Gray shale	3	
53.	Sandy shale	3	
54.	Sandstone	6	
55.	Black slate with trace of coal	2	
56.	Gray shale	82	
57.	Coal	1	
58.	Gray shale	10	
59.	Sandstone and shale	25	
	Thickness of coal measures	587	9
	Total depth of boring	942	

Another boring made previous to the one given above, located just north of the town, and carried to the depth of 539 feet, encountered only 270 feet of drift, showing that this deposit had increased in thickness about 70 feet in a distance of about half a mile, the increased depth being in a southerly direction. This would indicate that Clinton is located near the northern slope of this ancient valley.

I am inclined to regard the 2 feet 9 inches coal reported in this boring (No. 11) as probably the equivalent of the upper workable seam in the Bloomington shaft, and also of that in the shafts at Lincoln, Mt. Pulaski, and Decatur, and if so, it is much thinner at Clinton than at the points above named. Nos. 33 to 37 inclusive, represent a lower seam, that may be equivalent to Nos. 2 or 3 of the general section, and No. 57 may be regarded as No. 1.

After the publication of Vol. VII, the proprietors of the coal shaft at Mattoon put down a boring with the diamond drill to the depth of 203 feet, which probably reached the bottom of the coal measures.

For a detailed report of this boring, I am indebted to Walton Rutledge, Esq. Commencing below the coal in the shaft, which has been referred to coal seam No. 2 of the general section, the details of the boring are as follows:

	Ft.	In.
1. Fire clay	15	
2. Gray shale	70	
3. Black slate	1	
4. Coal	1	8
5. Fire clay	3	4
6. Dark shale	4	
7. Coal	0	4
8. Fire clay	1	8
9. Light shale	12	
10. Hard sand rock	4	
11. Sandy shale	27	
12. Dark shale	45	
13. Black slate	9	
14. Dark green shale	6	
15. Limestone	3	
Total thickness	203	

This, added to the 800 feet of coal measures passed through in the shaft, gives a total of about one thousand feet, and represents probably about three-fourths of the entire thickness of the coal measures in this State. Nos. 4 and 7 of the above record represent probably coal No. 1, which is often a double seam, and the limestone at the bottom belongs to the Lower Carboniferous formation.

A shaft at Smithboro, in Bond county, passed through two of the main coal seams in a depth of 498 feet, and a boring carried down from the bottom of the shaft reported another seam about forty-five feet below the lower seam in the shaft. The following is a copy in detail of the strata passed through in this shaft:

		Ft.	In.
1.	Soil and clay	15	
2.	Hardpan	60	
3.	Blue clay	10	
4.	Hardpan	10	
5.	Limestone	6	
6.	Light colored shale	12	
7.	Sandstone	12	
8.	Dark slaty shale	23	
9.	Very hard limestone	2	6
10.	Black slate	2	
11.	Coal, No. 9	1	
12.	Light yellow shale	30	
13.	Dark shale	17	
14.	Coal, No. 8	1	
15.	Slate, "	1	
16.	Coal, "	1	
17.	Shale and slate	62	
18.	Hard sandstone with salt water	100	
19.	Red shale	8	
20.	Clay shale	2	
21.	Sandstone	16	
22.	Shale	31	
23.	Limestone alternating with shale	12	
24.	Shale, broken coal and fragments of sandstone; horizon of coal No. 7	7	
25.	Brown fire clay	2	
26.	Light shale	8	
27.	Black slate	4	
28.	Limestone	4	
29.	Hard calcareous shale	4	
30.	Band of concretionary iron stone	1	
31.	Coal, No. 6	5	4
32.	Fire clay	2	6
33.	Gray limestone	9	
34.	Dark shale	3	
35.	Fire clay	4	
36.	Limestone	4	
37.	Coal, No. 5	4	6
38.	Fire clay	2	
	Total depth	498	10

The band of concretionary iron stone in the roof of coal No. 6, varies in thickness from six to twelve inches, and if the quantity was sufficient to justify its exploitation, it would be valuable for the production of iron. No. 24 seems to represent the horizon of another coal, which had been broken up and redeposited along with the bituminous shale and sandstone with which it was associated, and it probably represents the horizon of coal No. 7 of the general section. Coal No. 6 is the seam being worked here at this time, and it affords a product of fair quality. A heavy flow of salt water issues from the white sandstone No. 18, which is here a hundred feet in thickness.

A boring at Greenville, the county seat of Bond county, reported five and a half feet of coal at a depth of 488 feet from the surface. At this point the drift was found to be 200 feet in thickness, consisting largely of sand and gravel with so great an amount of water percolating through it that the parties interested were deterred from attempting to sink a shaft for the present. For the following record of this boring I am indebted to the Hon. J. P. Slade of Greenville:

		Ft.	In.
1.	Surface clay and soil	10	
2.	Sand and clay	20	
3.	Coarse sand	10	
4.	Gravel	20	
5.	Conglomerate	90	
6.	Clay and sand	20	
7.	Sand	8	
8.	Light colored clay and sand	8	
9.	Dark colored clay and sand	18	
10.	Gray limestone	5	
11.	Hard black slate	5	
12.	Light and dark shales	77	
13.	Sandstone and sandy shale	99	
14.	Clay shale	17	
15.	Sandy shale	5	
16.	Clay shale	27	
17.	Limestone	1	
18.	Clay shale	5	
19.	Limestone	9	
20.	Clay shale and green clay	10	
21.	Black fault	5	
22.	Clay and sandy shales	10	
23.	Limestone	3	
24.	Clay shale	4	
25.	Limestone	2	
26.	Coal	5	6
27.	Shale	7	
	Total depth	500	6

It is probable the coal seam at the bottom of this boring is No. 6, and the stratum numbered 21, which is described in the record as a black fault, represents the horizon of coal No. 7.

Greenville is undoubtedly located upon the line of one of the ancient valleys that were excavated either at the commencement of the drift period, or during the elevation of the surface above the carboniferous sea beneath which the coal measure rocks were formed, and by comparing the boring at Greenville with the shaft at Smithboro, we find the ancient valley attained a depth of about one hundred feet more at Greenville than at the latter point. A notable feature of the drift at Greenville, is the great amount of sand and gravel which it contains, and the small amount of clay. The 90 feet described as conglomerate by the men in charge of the boring, was probably a bed of gravel, cemented either with ferruginous or calcareous material such as may be frequently observed in surface outcrops of the drift deposits.

The coal shaft at Sorento, in Bond county, at a depth of 373 feet, penetrated a coal seam 8 feet in thickness. For the following copy of the record I am indebted to Mr. Walton Rutledge the mine inspector of that district:

No.		Ft.
1.	Soil and clay	17
2.	Conglomerate	28
3.	Clay shale	20
4.	Limestone	1
5.	Clay shale	4
6.	Light gray limestone	20
7.	Light limestone and chert	8
8.	Fire clay	1
9.	Black slate	3
10.	Clay shale	20
11.	Red shale	5
12.	Coal	1
13.	Fire clay	2
14.	Brown shale	30
15.	Light shale	12
16.	Clay shale	10
17.	Magnesian limestone	5
18.	Clay shale	20
19.	Brown shale	56
20.	Light shale	65

NOTE.—The sections of drift reported in connection with the coal shafts and borings given in this chapter, were mainly obtained after the preceding chapter was written, and tend to confirm the position hitherto assumed in regard to the origin of the drift beds, and demonstrate very clearly to the mind of the writer, that they are not the accumulations of land ice, but are largely if not wholly due to aqueous agencies. —A. H. W.

No.		Ft.
21.	Fire clay	8
22.	Light shale	27
23.	Light hard limestone	9
24.	Fire clay and slate	1
25.	Coal	8
26.	Fire clay and shale (dump)	20
	Total depth	401

The boring made at Sorento previous to sinking the shaft was carried to the depth of 612 feet without finding any other seam of coal of practical value. The following beds were passed through by the drill below the bottom of the shaft, as published in the Greenville Sun:

No.		Ft.
1.	Light shale	20
2.	Clay shale	30
3.	Hard limestone	4
4.	Slate	20
5.	Brown shale	18
6.	Limestone	1
7.	Sandy shale and sandstone	52
8.	Coal blossom?	4
9.	Hard yellow stone	4
10.	Slate	23
11.	Soft shale	35
		211
	Shaft	401
	Total depth	612

Although Sorento and Smithboro are but a few miles apart there is a marked change in the character of the beds encountered in the two shafts at these points. At Smithboro three seams of coal were found in a depth of 537½ feet while at Sorento a single seam only was encountered in a depth of 612 feet. Such sudden changes in the character of the strata are not of common occurrence in the Illinois coal field, though they have been rarely encountered at other localities.

Three coal shafts were commenced without a preliminary boring in Marion county, and all have been prosecuted to a successful issue; one at Kinmundy, and the others at Odin and Salem respectively. The shaft at Kinmundy, although the deepest of the three, was the first completed, reaching the horizon of coal No. 6 at the depth of 869 feet. The seam at this point was found to be divided by a parting of shale and limestone about seven feet in thickness, the upper division of the seam having a thickness of two feet two inches, and the lower of four feet two inches of good coal, while at Odin it is a solid seam of nearly seven feet in thickness.

The record of the Kinmundy shaft was very accurately kept by the gentleman in charge of the work, and it is a very important one, as it gives more than two hundred feet of upper coal measure strata not found at Odin or Sandoval. This is in part due to the greater elevation of the surface at Kinmundy, which according to the railroad level is 96 feet above Sandoval, and in part to the absence of the heavy deposit of drift, which was found both at Sandoval and Odin, and to the easterly dip of the strata.

The following is a slightly condensed copy of the record of the Kinmundy shaft.

No.		Ft.	In.
1.	Soil and brown clay	12	
2.	Sandstone and shale	134	5
3.	Pebbly limestone	1	4
4.	Black slate	9	7
5.	Coal, No. 15	1	2
6.	Fire clay	7	
7.	Gray shale	19	7
8.	Black slate	11	
9.	Coal, No. 14	1	6
10.	Fire clay	2	
11.	Shale	37	10
12.	Black slate	5	
13.	Bituminous limestone	2	
14.	Coal, No. 13	0	6
15.	Limestone and black shale	6	
16.	Coal	0	2
17.	Clay shale	5	6
18.	Gray and black shales with bands of limestone	51	
19.	Black slate	1	6
20.	Coal, No. 12.	1	
21.	Fire clay	1	6
22.	Limestone	3	
23.	Gray shale	15	9
24.	Black slate	3	
25.	Coal, No. 11	0	2
26.	Fire clay	2	10
27.	Shale and sandstone	66	6
28.	Coal, No. 10	0	4
29.	Fire clay	4	
30.	Limestone	3	
31.	Shale	81	
32.	Limestone (Shoal Creek)	9	10
33.	Black shale with 2 inch coal No. 9	2	
34.	Pebbly fire clay	5	

—5

	Ft.	In.
35. Sandstone and shale	76	
36. Pebbly limestone	1	6
37. Bituminous shale and ½ inch coal	2	6
38. Fire clay	5	
39. Sandstone and shale	69	
40. Black shale	0	10
41. Coal, No. 8	0	7
42. Fire clay	2	
43. Limestone, sandstone and fire clay	8	6
44. Blue shale	14	2
45. Limestone	21	6
46. Fire clay	2	
47. Green shale	1	6
48. Pebbly limestone	6	
49. Sandstone and shale	84	2
50. Coal, No. 7	2	
51. Fire clay	11	
52. Sandstone and shale	30	
53. Coal	2	2
54. Black shale	3	
55. Hard dark gray limestone	4	
56. Coal	4	2
Total depth	859	7

The limestone and shale parting in the coal at Kinmundy, is a feature that I have observed nowhere else in the state. It is probably a local development only, and may wedge out in some direction in a short distance. In whatever direction the coal thickens as the work of exploitation progresses, it should be followed, with the expectation that the two divisions will gradually approach each other by the thinning out of the stony parting until they finally come together.

A boring to the depth of about 130 feet from the bottom of the shaft, reported only one seam of coal about eighteen inches thick about seventy feet below the main coal.

An analysis of two samples of coal from the Kinmundy shaft, by Prof. Barrett of the University of Illinois, gave the following result:

FIRST SAMPLE.		SECOND SAMPLE.	
Ash	12.54	Ash	13.13
Moisture	8.40	Moisture	8.32
Fixed carbon	48.04	Fixed carbon	48.66
Volatile matter	30.26	Volatile matter	30.03
	99.24		100.04

Per cent. of sulphur in coal	2.85
Per cent. of sulphur in coke	0.97

The following copy of the record of the Odin shaft will be of interest for comparison:

		Ft.	In.
1.	Drift clay and gravel	100	
2.	Nodular shale	1	3
3.	Coal, No. 12	0	9
4.	Shale and fire clay	39	
5.	Coal and black shale	3	10
6.	Shale and fire clay	14	6
7.	Coal, No. 11	0	7
8.	Sandy shale and sandstone	20	
9.	Blue clay and fire clay	12	6
10.	Calc. sandstone, fossiliferous	8	
11.	Blue shale	3	
12.	Coal (local)	0	2
13.	Fire clay	0	6
14.	Sandy shale	14	2
15.	Coal, No. 10	0	7
16.	Sandy and arg. shales	63	
17.	Limestone (Shoal Creek)	10	
18.	Black slate and 2 in. coal, No. 9	3	2
19.	Fire clay	5	
20.	Sandstone and shale	56	6
21.	Blue shale with limestone bands	11	10
22.	Fire clay	5	
23.	Slate and limestone	8	
24.	Clay shale	10	
25.	Sandstone	63	
26.	Blue shale	28	
27.	Nodular black shale	7	
28.	Coal, No. 8	0	10
29.	Fire clay	2	6
30.	Sandstone and shale	117	
31.	Pebbly shale and fire clay	11	
32.	Limestone, partly hard	14	
33.	Blue shale	10	6
34.	Coal (local)	1	4
35.	Fire clay and shale	10	8
36.	Coal, No. 7	3	2
37.	Fire clay	4	
38.	Alternations of shale and limestone	26	
39.	Black shale	4	
40.	Coal, No. 6	7	
	Total depth	701	4

The Kinmundy shaft is eleven miles north, and about twelve miles east of Odin, and the subjoined condensed vertical section of the coal measures encountered at these two points, placed side by side for comparison, will serve to show the uniformity of their development in this portion of the State.

Odin Shaft.

	Ft.	In.
Shale	1	3
Coal No. 12	0	9
Shale, slate, etc	48	
Coal No. 11	0	10
Shale, fire clay, etc	58	
Coal No. 10	0	7
Shale, limestone, etc	72	
Coal No. 9	0	2
Sandstone, shale, etc	196	
Coal No. 8	0	10
Limestone, shale, etc	155	
Coal No. 7	3	2
Limestone, shale and slate	34	
Coal No. 6	7	

Kinmundy Shaft.

	Ft.	In.
Sandstone and shale	146	
Coal No. 14	1	4
Shale and slate	38	
Coal No. 13	1	6
Limestone, shale, etc	62	
Coal No. 12	0	8
Shale, slate, etc	23	
Coal No. 11	1	
Shale, slate, etc	68	
Coal No. 10	0	
Shale, limestone, etc	88	
Coal No. 9	0	2
Sandstone, shale, etc	160	
Coal No. 8	0	4
Limestone, shale, etc	142	
Coal No. 7	2	
Limestone, shale and slate	41	
Coal No. 6	6	4

At Salem the shaft was sunk to the depth of 886 feet, and the following details were furnished by Mr. R. S. Dingle who was in charge of the work.

The drift deposits were found to be 126 feet thick with the ancient soil in place about ten feet from the bed rock.

No.		Ft.	In.
1.	Soil and subsoil	1	10
2.	Hardpan	3	
3.	Yellow clay	9	
4.	Yellow clay and sand	10	
5.	Blue clay and gravel	50	
6.	Brown clay with wood	30	
7.	Blue clay, sand and wood	12	
8.	Black soil	1	
9.	Blue mud and sand	9	2
10.	Sandstone	0	6
11.	Clay shale	8	
12.	Black limestone	1	10
13.	Coal	1	2
14.	Fire clay	1	7
15.	Conglomerate of lime and sand	4	7
16.	Blue shale and slate	26	
17.	Clay shale	17	
18.	Sandy shale	10	
19.	Dark blue shale	11	2
20.	Coal	0	5
21.	Fire clay	0	7
22.	Dark blue shale with sand partings	9	
23.	Light blue limestone	7	8
24.	Fire clay	3	

No.		Ft.	In.
25.	Sandy shale	3	
26.	Clay shale	8	
27.	Coal	0	4
28.	Fire clay	0	10
29.	Sandstone and sandy shale	54	
30.	Blue shale	7	
31.	Gray shale	5	6
32.	Dark blue shale	5	4
33.	Gray limestone	5	
34.	Fire clay	2	3
35.	Sandstone	11	
36.	Clay shale	14	9
37.	Bituminous shale	2	6
38.	Coal	0	9
39.	Fire clay	0	3
40.	Conglomerate of lime and sandstone	3	6
41.	Sandstone and sandy shale	35	
42.	Clay shale	22	
43.	Light gray limestone	12	
44.	Hard massive sandstone	8	
45.	Sandy shale	21	
46.	Clay shale	23	
47.	Coal	0	4
48.	Fire clay	1	2
49.	Conglomerate lime and sandstone	7	
50.	Shale and slate	25	4
51.	Limestone (Shoal Creek)	14	
52.	Black slate	3	
53.	Coal	0	2
54.	Fire clay	4	6
55.	Sandstone and sandy shale	61	6
56.	Blue shale	8	
57.	Conglomerate of lime and sandstone	1	6
58.	Black slate	2	2
59.	Gray limestone	0	6
60.	Coal	0	1
61.	Fire clay	4	3
62.	Nodular clay shale	8	
63.	Blue slate	1	
64.	Coal	0	4
65.	Blue slate	1	8
66.	Hard sandy shale	10	4
67.	Dark blue slate	2	8
68.	Conglomerate of lime and sandstone	5	3
69.	Sandy shale and sandstone	16	3
70.	Shale and slate	31	
71.	Brown limestone	0	2
72.	Clay shale and slate	6	4
73.	Limestone	1	
74.	Blue slate	6	
75.	Coal	1	4
76.	Fire clay	1	6
77.	Nodular shale (calcareous)	8	
78.	Sandstone and sandy shale	33	9
79.	Blue shale	44	

No.		Ft.	In.
80.	Fire clay	1	5
81.	Conglomerate of lime and sandstone	3	
82.	Fire clay	7	
83.	Dark gray limestone	9	
84.	Clay shale	19	6
85.	Coal	0	6
86.	Fire clay	3	6
87.	Limestone with clay partings	19	6
88.	Sandy shale	33	
89.	Blue slate	0	4
90.	Coal	2	2
91.	Fire clay	0	10
92.	Black slate	2	2
93.	Gray limestone	2	
94.	Black slate	1	6
95.	Coal	4	6
96.	Fire clay	4	3
	Total thickness	899	3

The strata reported above seem to be about 13 feet more in thickness than the depth of the shaft as measured after the completion of the work.

A boring at Hillsboro, in Montgomery county, made by the Chicago Diamond Drill Company, was carried to the depth of 769 feet, and penetrated through the lower coal measures, and into the upper division of the Lower Carboniferous formation. The following is a copy of this boring kindly furnished by Mr. Geo. C. Bryce:

		Ft.	In.
1.	Yellow clay, sand and pebbles	14	
2.	Hardpan	23	
3.	Quicksand	1	
4.	Hardpan	16	
5.	Yellow clay	7	
6.	Sand and gravel	20	
7.	Blue clay	26	
8.	Coarse sand and gravel	16	6
9.	Limestone	8	
10.	Clay shale	52	6
11.	Limestone (Shoal Creek)	8	
12.	Bituminous shale	1	8
13.	Coal, No. 9	0	8
14.	Clay shale	29	8
15.	Sandy shale and sandstone	65	
16.	Fire clay. (Horizon of coal No. 8)	8	
17.	Sandy shale	24	
18.	Sandy slate	78	
19.	Clay shale, upper part nodular	9	
20.	Hard limestone	5	6
21.	Clay shale	11	6
22.	Limestone	6	

No.		Ft.	In.
23.	Bituminous shale	3	
24.	Limestone	5	8
25.	Clay shale	7	4
26.	Hard limestone	7	6
27.	Bituminous shale	6	
28.	Coal, No. 6	5	
29.	Sandy shale and sandstone	8	
30.	Argillaceous limestone	11	
31.	Clay shale	9	
32.	Argillaceous limestone	10	
33.	Slate with hard bands	19	
34.	Sandy shale	33	
35.	Coal 1 foot, slate 6 in., coal 1 foot—No. 5	2	6
36.	Slate	2	6
37.	Sandstone	8	6
38.	Slate	33	
39.	Sandstone	5	
40.	Limestone	1	
41.	Bituminous shale and coal	2	
42.	Fire clay	8	
43.	Bituminous shale and coal	2	
44.	Fire clay	5	
45.	Slate with clay bands	10	
46.	Coal	1	
47.	Fire clay	12	
48.	Sandstone	8	
49.	Fire clay	1	
50.	Bituminous shale	1	
51.	Sandstone	131	
52.	Limestone	10	
	Total depth	769	

The drift at Hillsboro was found to be 123½ feet in thickness, and contains some very clean beds of gravel near the bottom, which outcrop at the base of the hill near the railroad depot.

The stratum, numbered 35, is probably coal No. 6, which holds about its average position here below the Shoal Creek limestone. Coal No. 8 belongs above the fire clay No. 16 of the section, but no bituminous matter seems to have been brought up from that horizon by the drill.

From an examination of the core taken from the bottom of this boring, it was evident that it had penetrated the Chester division of the Lower Carboniferous, the purple shale and argillaceous limestone of that formation, being readily recognized. A portion and possibly the whole of the sandstone No. 51 of the record, and the underlying limestone, No. 52, belong to that horizon.

Since the publication of Vol. VII, an air shaft was sunk at Decatur, the details of which were furnished for publication by Charles Hansel, Esq., resident engineer of the middle division of the Wabash, St. Louis and Pacific Railway. It is published as a correction of the boring made with a common drill before the coal shaft was sunk, a copy of which was published in Vol. VII, page 17 et seq. of these reports. The air shaft is located about half a mile south-west of the coal shaft, near the bluffs of the Sangamon river. The following is a copy in detail of the record kept:

No.		Ft.	In.
1.	Soil and loamy clay	25	
2.	Sand and water (flow of 400 gallons per minute)	30	
3.	Blue clay	4	
4.	Drift wood and soil	2	
5.	Green sand	4	
6.	Gray sand	6	
7.	Hard blue clay	9	
8.	Sand and gravel (five strata)	37	
9.	Hardpan	23	
10.	Sandstone	1	6
11.	Soft shale	6	
12.	Gray and blue sandy shale	28	
13.	Clay shale	15	
14.	Blue slate	17	
15.	Ferruginous fire clay	6	
16.	Conglomerate limestone	7	
17.	Brown slate	10	
18.	Flint stone	2	6
18.	Black slate	1	
19.	Flint rock	2	6
20.	Coal, No. 11	0	10
21.	Fire clay	8	
22.	Blue sandy shale	10	
23.	Flint stone	3	
24.	Clay shale	5	
25.	Sandy shale	21	
26.	Black slate	2	6
27.	Coal, No. 10	1	
28.	Fire clay	6	
29.	Black shale and 1 inch of coal	8	1
30.	Fire clay	6	
31.	Black shale	3	
32.	Impure limestone	1	
33.	Brown shale	8	
34.	Sandstone	1	
35.	Black slate	4	
36.	Flint stone	11	
37.	Black slate	12	
38.	Fire clay	4	
39.	Limestone (Shoal Creek)	10	
40.	Black slate (coal No. 9)	2	
41.	Fire clay	8	

No.		Ft.	In.
42.	Clay shale	13	
43.	Sandstone	5	
44.	Flint stone	2	
45.	Blue slate	8	
46.	Clay shale	39	
47.	Blue sandstone	1	
48.	Black slate	3	
49.	Coal, No. 8	1	4
50.	Fire clay	6	
51.	Sandy shale	10	
52.	Black shale	33	
53.	Hard black slate	5	
54.	Coal (local)	0	3
55.	Fire clay	4	
56.	Limestone	11	
57.	Black shale	4	
58.	Clay shale	2	
59.	Coal (coal No. 7)	0	4
60.	Fire clay	2	
61.	Conglomerate stone	3	
62.	Gray and blue clay shale	14	
63.	Black slate and ½ inch of coal	4	
64.	Fire clay	4	
65.	Sandstone	7	
66.	Gray shale	6	
67.	Black slate	2	
68.	Coal,........ (Coal No. 6)	1	4
69.	Clay shale, (" " ")	0	6
70.	Coal,........ (" " ")	2	10
71.	Hard gray shale	8	
72.	Limestone	2	6
73.	Bituminous shale and coal	0	6
74.	Fire clay	4	
75.	Sandstone	17	
76.	Clay shale	3	
77.	Sandstone	13	
78.	Dark clay shale	8	
79.	Black slate	1	6
80.	Coal, No. 5	4	6
	Total depth	528	6

No. 49 of the above record is the equivalent of No. 35 in the boring at Decatur, published in Vol. VII, page 18, and represents coal No. 8 of the general section. In the record of the boring it is described as a six-foot seam of coal, but is really a thin coal, overlaid by four or five feet of bituminous shale. It requires a very close and careful inspection to distinguish coal from bituminous shale in the pulverized material brought to the surface in the sand pump from a boring with the common drill, and in the majority of the borings of that kind made in this State, the reported results have proved misleading when a shaft has been sunk to the horizon of the coal reported, entailing in many cases a heavy loss to the company undertaking the work. With the diamond drill this uncertainty is easily avoided.

The beds described as flint rock in the air shaft record, are probably hard silicious limestones which are not uncommon in the Illinois coal measures, while beds of true chert (miscalled flint) are of rare occurrence.

Two experiments for the developement of coal in Morgan county, were undertaken shortly after the publication of Vol. VII. Both extended to the bottom of the coal measures, and a condensed copy of the two records is herewith given side by side for comparison. The experiment made at Franklin was by a shaft, and that at Waverly by boring.

Franklin.			Waverly.		
No.	Ft.	In.		Ft.	In.
1. Drift clay	35		Drift clay	25	
2. Sandstone	25		Sandstone and slate	17	6
3. Coal	0	9	Coal	0	5
4. Fire clay shale etc	134		Fire clay, shale, etc	153	
5. Limestone	7		Limestone	6	6
6. Coal	4	6	Coal	1	3
7. Fire clay, shale, etc	85		Fire clay, shale, etc	141	
8. Coal	1	2	Coal	3	
9. Fire clay, shale, etc	40		Fire clay, shale	55	
10. Coal	2	6	Coal	1	4
11. Fire clay	6		Fire clay	1	
12. Limestone			Limestone		

No. 6 probably the equivalent of the Springfield coal, No. 5 of the general section, while the lower seams Nos. 8 and 10 represent coals 1 and 2, and No. 12 the upper bed of the lower carboniferous group.

About the same time a shaft was sunk at Mt. Pulaski in Logan county and one about a mile northeast of Lincoln in the same county. Of the latter I have been unable to obtain a record, and for that at Mt. Pulaski I am indebted to Mr. Beard of Springfield under whose supervision the work was done:

No.		Ft.	In.
1.	Drift clay and gravel (details not preserved)	92	
2.	Sandy shale	20	
3.	Limestone	1	
4.	Fire clay	1	6
5.	Gray slate	20	
6.	Sandy shale	40	
7.	Limestone	2	
8.	Black shale	1	
9.	Coal No. 8	1	6
10.	Fire clay	2	
11.	Clay shale	4	
12.	Gray shale (sandy)	60	
13.	Conglomerate limestone	15	
14.	Clay shale	2	
15.	Black slate	1	
16.	Coal 6 inches, fire clay 6 inches	1	
17.	Black slate 10 inches, coal 4 inches	1	2
18.	Fire clay	0	8
19.	Reddish shale	10	
20.	Sandstone	30	
21.	Sandy clay shale	30	
22.	Black limestone	8	
23.	Coal No. 5	4	
24.	Fire clay	4	
	Total depth	351	10

The Medora shaft is located on the west line of Macoupin county, and reaches the bottom of the coal measures. The following strata were passed through at that point.

No.		Ft.	In.
1.	Black soil	4	
2.	Yellow clay	20	
3.	Blue clay	30	
4.	Drift gravel	20	
5.	Clay shale	10	
6.	Shale	4	
7.	Blue limestone	2	
8.	Black slate	3	
9.	Coal	0	5
10.	Fire clay	4	
11.	Gray slate	5	
12.	Sandstone	5	
13.	Clay shale	5	
14.	Shale	5	
15.	Black slate	3	
16.	Coal	1	
17.	Fire clay	4	
18.	Red clay shale	0	8
19.	Sandstone	8	
20.	Limestone	2	
21.	Nodular clay	5	
22.	Clay shale	5	
23.	Clod?	1	

No.		Ft.	In.
24.	Limestone	6	
25.	Clay shale	2	
26.	Black slate	2	6
27.	Clay shale	6	
28.	Light shale	9	6
29.	Blue fire clay	6	4
30.	Clay shale	2	10
31.	Sulphur band	0	8
32.	Fire clay	3	
33.	Nodular clay	4	
34.	Fire clay	14	7
35.	Sandstone	12	4
36.	Shale	50	2
37.	Gray shale	19	5
38.	Clay shale	6	6
39.	Gray shale	7	6
40.	Black slate	1	4
41.	Sandy shale	6	4
42.	Gray shale	30	7
43.	Black slate	2	
44.	Coal	3	
45.	Fire clay	1	8
46.	Hard limestone	6	
	Total depth	351	4

No. 44 is the lowest seam developed in this portion of the State, and is probably identical with that of the Roodhouse shaft in Greene county, and the Alton coal of Madison county. It varies in thickness from two to four feet, and has a good roof of hard bituminous shale which at some points contains beautiful fossil shells, in which the calcareous matter is replaced with bright yellow pyrites of iron. The coal itself is also more or less impregnated with the bi-sulphurate of iron.

A shaft at Elkville, in Jackson county, reports nine feet of coal at the depth of 110 feet below the surface. The following record of this shaft was furnished by Mr. Robert Winning, mine inspector of that district:

No.		Ft.	In.
1.	Drift clay and soil	33	10
2.	Sandstone	7	
3.	Clay shale	15	
4.	Black slate	1	10
5.	Fire clay	2	2
6.	Limestone	7	
7.	Dark blue slate	4	2
8.	Coal	2	2
9.	Fire clay	0	9
10.	Sandstone	4	

No.		Ft.	In.
11.	Dark slate	4	
12.	Fire clay	3	6
13.	Coal	1	2
14.	Fire clay	8	10
15.	Limestone	4	
16.	Blue slate	2	10
17.	Limestone	4	4
18.	Dark slate	1	6
19.	Black limestone	4	
20.	Black slate	7	
21.	Clay shale	0	9
22.	Coal	9	2
	Total depth of shaft	129	

This is probably the same coal that outcrops four miles northeast of Ora, on Rattlesnake creek, which I have referred to the horizon of coal No. 1 of the Illinois section. The reported thickness of the seam in this shaft is greater than it has been found elsewhere in the state, but it is usually a very irregularly developed seam.

One of the most important developments of coal in Southern Illinois within the past two years, is the opening up of the outcrops on Rattlesnake creek in Jackson county, referred to above, near the center of township 7 south, 3 west. This outcrop was mentioned in the report on Jackson county, Vol. 3, page 74 of these reports, but no attempt to work the seam, except in a very limited way, was made until recently, for the want of proper facilities for transportation. Since the construction of what was formerly known as the St. Louis and Cairo Narrow Gauge Railroad, now known as the Mobile and St. Louis Railroad, a tramway has been constructed two miles north of Ora, extending from the above named railroad to the mines, a distance of about two miles.

This was done by Messrs. J. C. Bryden & Co., who have established a plant on the outcrop of the seam, capable of furnishing from three to four hundred tons of coal per day, with a mining force of one hundred to one hundred and twenty-five men. The seam varies in thickness at the several outcrops in this township from four to seven feet, and is enclosed between two beds of sandstone. Sometimes the upper sandstone rests directly on the coal, and at other points is separated from it by a thin bed of argillaceous shale.

The coal is quite free from the bi-sulphuret of iron, yields a white ash, and is said to leave no clinker when used for domestic purposes. On sec. 22, its position is rather above the drainage lèvel of some of the small streams, and consequently has been cut out by erosive agencies in the creek valleys.

This seam appears to hold about the same stratigraphical position as that known as the Battery Rock coal in Gallatin county, which is the lowest workable seam in Southern Illinois. Its development in Jackson county is somewhat local, and appears to be restricted to the township in which the mines are located. It has not been found in Randolph county, though the lower portion of the coal measures are there well exposed. At Murphysboro, twelve miles southeast of the Rattlesnake mines, no indications of its presence has been found, though it may be the equivalent of the seam near Makanda, in the south-east corner of Jackson county.

The two following borings in Southern Illinois were made and reported by Mr. Wm. McDonald. One was made three miles southwest of Harrisburg in Saline county, and the other near New Burnside in Johnson county. The latter probably commences below the lowest stratum reached in the former, and ends before reaching the bottom of the coal measures.

The following is a condensed copy of the record of the boring in Saline county:

No.		Ft.	In.
1.	Surface soil and clay	14	
1.	Sandstone and shale	61	
3.	Limestone	0	6
4.	Black slate	0	9
5.	Coal, (Coal No. 6)	2	4
6.	Fire clay	1	
7.	Sandy shale and sandstone	29	7
8.	Limestone	1	9
9.	Black slate	3	8
10.	Shale with limestone bands	22	4
11.	Black slate	0	6
23.	Coal (coal No. 5)	4	10
	Total depth	142	3

The following is a condensed copy of the record of the boring near New Burnside:

No.		Ft.	In.
1.	Surface soil	1	
2.	Sandstone and shale	59	3
3.	Black shale	3	11
4.	Coal	1	3
5.	Soft gray shale	2	1
6.	Coal	3	
7.	Black shale	3	4
8.	Fire clay	1	2
	Total depth	75	

A boring at Effingham, which commences in about the highest strata of the upper coal measures, was carried to the depth of 1,176 feet, passing through three workable coals in that distance. For the following copy of the record of this boring I am indebted to Walton Rutledge, Esq., Mine Inspector of that district:

No.		Ft.	In.
1.	Yellow clay	16	
2.	Hardpan	10	
3.	White sandstone	6	
4.	Sandstone and shale	96	
5.	Blue limestone	2	
6.	Black shale	3	
7.	Sandstone and shale	187	
8.	Limestone	2	
9.	Shale	72	
10.	Bituminous shale	1	
11.	Coal	0	
12.	Shale	35	
13.	Coal	1	
14.	Fire clay	2	
15.	Sandstone and shale	19	
16.	Coal	0	8
17.	Calcareous shale	6	4
18.	Limestone	7	
19.	Blue shale	7	
20.	Limestone	7	
21.	Calcareous shale	3	
22.	Shale	44	
23.	Coal	0	3
24.	Sandy shale	4	9
25.	Coal	0	8
26.	Shale	71	4
27.	Black slate	2	
28.	Shale and sandstone	43	
29.	Coal	1	2
30.	Blue shale	7	10
31.	Black slate	2	
32.	Shale, part sandy	53	
33.	Limestone	6	
34.	Black shale	4	
35.	Gray shale	52	

No.		Ft.	In.
36.	Black slate	12	
37.	Shale, part sandy	37	
38.	Limestone	3	
39.	Shale	23	
40.	Limestone and calcareous shale	36	
41.	Gray shale and slate	117	
42.	Black shale	10	9
43.	Coal	3	
44.	Dark shale	5	3
45.	Limestone	3	
46.	Slate	4	4
67.	Coal	4	6
68.	Fire clay	3	2
69.	Limestone	10	
70.	Sandstone	9	
71.	Slate	2	
72.	Coal	1	2
73.	Fire clay	0	10
74.	Dark slate	3	4
75.	Coal	4	8
76.	Gray shale	2	
77.	Limestone	19	
78.	Sandstone and shale	69	
79.	Black shale	10	
80.	Gray shale	7	
	Total depth	1,176	

I regard the three coals near the bottom of this boring as the equivalents of coal numbered 5, 6 and 7 of the general section, No. 5 being here a divided seam, and represented by Nos. 72 to 75 inclusive of the above record. They are all of sufficient thickness to be advantageously mined, but the depth at which they are found may prove a detriment to their immediate exploitation.

At Mount Vernon a boring with the diamond drill penetrated a seam of coal 5½ feet thick at the depth of 546 feet. No detailed copy of the record could be obtained.

Record of a diamond drill boring at Galum creek, Perry county, on the W. C. & W. R. R.

	Ft.	In
Surface soil and clay	17	6
Black shale	1	10
Dark blue limestone	8	8
Black shale	2	6
Coal No. 6	5	10
Fire clay	1	6
Limestone	1	3
Soft white shale	2	3

	Ft.	In.
Light gray limestone	2	
Sandy shales	7	10
Hard white limestone	6	7
Hard gray shale	2	
Hard blue limestone	0	6
Coal No. 5	4	8
Fire clay	11	1
Limestone	0	9
Shale	2	
Sandy shale and sandstone	52	6
Blue shales with limestone nodules	5	3
Fossiliferous limestone	1	4
Black shale	8	3
Coal.............(Coal No. 4)	3	1
Gray clay shale (" " ")	1	8
Coal.............(" " ")	0	2
Dark shales with sulphur nodules	2	4
Gray shales	1	7
Black shale with limestone nodules	6	3
Shale	13	10
Black slate	2	9
Coal No. 3	2	2
Shale	8	6
Limestone	0	9
Shale and sandstone	3	9
Shales with thin bands of limestone	15	7
Shale	9	8
Coal.......................(Coal No. 2)	1	6
Clay shale and limestone.(" " ")	1	5
Coal.......................(" " ")	2	6
Fire clay	1	7
Gray shale and sandy limestone	1	4
Shales with limestone nodules	9	9
Shale	12	9
Sandstone	4	6
Black shales	1	11
Coal No. 1	3	5
Black slate	0	5
Dark sandy shales	8	7
Gray shale with limestone nodules	1	9
Shale	13	5
Coal (local)	1	7
Dark shale with limestone nodules	2	2
Sandy gray shales	6	9
Slate and shale with traces of coal	5	5
Shales	28	9
White sandstone with traces of coal	1	
Coarse sandstone	14	8
Pebbly conglomerate	1	
Total depth	344	4

The boring of which the above is a correct record was made on the line of the Wabash, Chester & Western R. R. in Perry county. It shows the presence at that point of all the lower

—7

coals from No. 6 to the bottom of the measures the boring terminating in the pebbly conglomerate which lies at the base of the coal measures in southern Illinois. For a copy of this record I am indebted to the Hon. C. B. Cole of Chester.

NATURAL GAS AND OIL.

Deposits of natural gas have been found at various localities in the State, but they were generally in the drift clays that overlie the stratified rocks. This fact has led the writer to conclude that such deposits did not originate in the older formations of Devonian and Silurian age, from which the main supply of this material is obtained in Ohio and Pennsylvania, but had been generated in one of the old peaty soils, which are interstratified with the drift clays, and are found intact over extensive areas in Illinois.

Since the publication of Vol. VII of these reports, several discoveries of this kind have been made, among which are two in the edge of DeWitt county, eight miles west of the city of Clinton, which are worthy of special notice. In the summer of 1885, Mr. James Barnet, who resides at the locality given above, while boring for water, found gas at two localities on his farm. The first well was carried to the depth of ninety-six feet below the surface, when a flow of gas was encountered with a pressure of about twelve pounds to the square inch. Abandoning his search for water there, he moved his tools to another locality but a short distance away, and at the depth of 137 feet he obtained another flow of gas with a pressure of thirty pounds to the square inch. This hole was tubed and pipes laid to his dwelling, where the gas was utilized for heating and cooking purposes. When the gas producing stratum was reached, sand and pebbles where thrown to the surface, indicating clearly the porous character of the material in which the gas had been confined. The following beds were encountered in boring the deepest well:

	Ft.
Soil and yellow clay	15
Blue clay	30
Black soil with wood, &c	3
Drab clay	8
Black mold and drift wood	8
Drab colored clay	20

Drift wood (log?)	2
Drab colored clay	21
Hardpan	12
Drab colored clay	3
Greenish clay	10
Sand, &c.	5
Total depth	137

The sand bed at the bottom of this well served as a receptacle for the gas, which was held imprisoned by the impervious green clay above until it was penetrated by the drill, and thus given a free outlet to the surface.

Indications of the presence of gas in the drift clays have been observed at several localities in northern and central Illinois, but whether it is generated in the deposit where it is found, or in the stratified rocks below, is an unsolved problem, that must be settled by future investigations. Its presence is purely local, and two borings with the diamond drill at Clinton, which passed entirely through the drift deposits, and extended into the underlying coal measures failed to reveal the presence of gas at either point.

In 1871, gas was found on the farm of Wm. A. Wilson, in Macon county, ten miles south-east of Decatur, at the depth of forty-five feet below the surface. It was stored in a bed of quick sand below a deposit of hardpan, and was encountered at several localities on the farm. The bed of quicksand was penetrated to the depth of fifteen feet without reaching the bottom. The character of the underlying bed was not determined, but if it was shown to be one of the old mucky soils frequently interstratified with the drift beds, that would furnish a possible explanation of the origin of the gas. Mr. Wilson utilized the flow by conveying it to his dwelling, where it was used for a time for both light and fuel.

A quarter of a mile east of this gas well a boring was made, which passed through a bed of black soil, but no gas was found. This might be due to the character of the overlying stratum, which may have been too porous to prevent the escape of the gas to the surface.

Gas from the superficial deposits of drift clay and gravel, has been found in numerous localities in Illinois, but generally not in such quantity as to justify any attempt to utilize it for domestic uses. The counties of Champaign, Bureau, LaSalle, Livingston, McLean and Madison are among those in which such discoveries have been made.

The only localities in this State where productive gas wells have been obtained in the stratified rocks are Litchfield, in Montgomery county, and in a well but just completed at Beardstown, on the Illinois river. The discovery at Litchfield was made in 1879, by the Litchfield Coal Co., of which Mr. H. H. Beach is President. It was made in a boring at the bottom of their coal shaft, carried down to the depth of 168 feet below the coal seam mined at that point, and the gas was encountered in a light colored sandstone, about 100 feet below coal No. 1. No attempt was made to develop this gas deposit for several years after its discovery by the Litchfield Coal Co., but eventually a company was formed for the purpose of developing the oil and gas deposits of Montgomery county, under the name of "The Litchfield Oil, Gas, and Fuel Company," and at the commencement of the current year sixteen wells had been sunk there, three of which were productive in gas, and three in oil.

The productive wells are all on a nearly north and south line, and those sunk on either side of this line, though but a short distance from it, failed to prove productive. This fact indicates the existence of an anticlinal, and the probable fracture of the lower strata thus permitting the gas to rise to the sandstone in which it is found. Hence the formation in which the gas is generated cannot be certainly determined, and may be either of Lower Carboniferous, Devonian or Silurian age.

The boring at Olney, the deepest one hitherto reported in Southern Illinois, produced no gas, although carried down about seven hundred feet below the base of the coal measures, and two thousand feet below the surface.* It probably did not reach Devonian strata, and therefore affords no evidence for determining whether or not the Devonian and Silurian rocks will afford productive gas wells in Southern Illinois.

The Litchfield Oil, Gas and Fuel Company have succeeded in introducing gas as fuel in many of the dwellings in Litchfield,

*The record of this boring may be found on page 8, of Vol. VII, of these reports.

and at the present time (February, 1887,) they have about 400 meters in use with an average consumption of about 1,500 feet each per day.

Three oil wells were in operation at the above date, affording an average yield of seven or eight barrels of crude oil per day, or a little more than two barrels per day to each well.

The well recently sunk at Beardstown to the depth of 1,070 feet, obtained a flow of artesian mineral water amounting to about 800 barrels per day. Both oil and gas was found here, the latter, although not fully tested, is supposed to have a pressure of several hundred pounds to the square inch, but the quantity of oil is only about half a gallon per day. The principal flow of gas appeared to come from the Trenton limestone.* The following record of this well was furnished by Dr. H. Ehrhardt, President of the company:

No.		Feet
1.	Drift clay, sand and gravel	90
2.	Limestone (Lower Carboniferous)	145
3.	Kinderhook and Hamilton shales	250
4.	Porous Magnesian limestone (Niagara)	70
5.	Shales and slate (Cincinnati group)	125
6.	Trenton limestone	375
7.	St. Peters sandstone, penetrated only	15
	Total depth	1,070

The first flow of oil and gas was said to have come from the lower portion of No. 3, which probably represents the horizon of the Devonian system, but the principal flow of water came from the St. Peters sandstone. The company will probably put down some additional wells to further test their territory.

The gas question has excited considerable interest in the public mind for the last two or three years, in consequence of the discoveries made in Ohio and Pennsylvania, and several experimental wells have been sunk in search of this much desired fuel, but with the exception of the one at Beardstown, none of them have proved successful. Most of the borings made in central and northern Illinois for artesian water have been carried down

*The first flow of oil and gas was found in the Devonian rocks, but was thought to increase in quantity when the drill penetrated the Trenton limestone.

into the St. Peters and Potsdam sandstones, but none of them hitherto reported, except the well at Beardstown, have produced either gas or oil in paying quantities.

The boring at Riverton, seven miles east of Springfield, was carried to the depth of 2,004 feet below the horizon of coal No. 5, and about 1,380 feet below the base of the coal measures. From the detailed record furnished by Mr. Swan, under whose direction the work was done, it is impossible to define the exact horizon where the bore terminated, but it undoubtedly passed entirely through both the productive gas horizons of Ohio and Pennsylvania. Neither oil, gas or artesian water was found in this well.

The artesian well at Carthage, in Hancock county, encountered the St. Peters sandstone at the depth of 975 feet, where a fine flow of mineral water was obtained, but no indication of the existence of any productive deposit of oil or gas was observed.

The artesian well at Monmouth reached the St. Peters sandstone at the depth of 1,088 feet, but no flow of water was obtained, and no indication was found of the presence of gas or oil. At Canton in Fulton county a well was bored through both the gas producing horizons without obtaining either gas or artesian water, and in northern Illinois many successful artesian wells have been sunk, all passing through the Trenton limestone, the lowest formation from which gas has as yet been obtained, without in a single instance obtaining gas sufficient to justify its utilization.

At Canton, a boring was made to the depth of 2,333 feet by Messrs. Atwater & Co. in search of artesian water, which proved a failure. The St. Peters sandstone was reached at the depth of 1,415 feet, but no flow of either water or gas was obtained from it.

The following is a condensed copy of the record of this well.

No.		Feet.
1.	Drift, clay, etc	92
2.	Coal measure shales, etc	208
3.	Lower carb. limestone	299
4.	Kinderhook shales	171
5.	Limestone (Devonian)	64

	Feet.
6. Limestone (Up. Silurian)	150
7. Shale, etc., (Cincinnati group)	150
8. Trenton limestone	280
9. St. Peters sandstone	273
10. Calciferous limestone	100
11. Potsdam sandstone	545
Total depth	2,332

In all the artesian wells of northern Illinois, and they may be counted by the score, not one except the well at Beardstown already referred to, has yielded any notable quantity of gas, and with such facts before me I have felt it to be my duty to discourage any large expenditure of money in central or northern Illinois, in attempts to develop productive gas wells in those portions of the State.

In the eastern and southern portions of the State the conditions are more favorable, but no experiments have as yet been made that would justify the expression of a decided opinion upon the gas question there. The only deep well bored in southern Illinois of which I have been able to obtain the record is that at Olney, which is given in detail on page. 8, of Vol. VII, of these reports. Although this boring was carried to the depth of 2,000 feet, yet it did not reach the base of the lower carboniferous limestone, and therefore affords no evidence in regard to the development of the gas producing formations of Ohio and Pennsylvania, which lie from 1,000 to 1,500 feet below the lowest stratum penetrated in the Olney boring.

The Devonian system is fairly well developed in southern Illinois, attaining a maximum thickness of 350 to 400 feet. The following divisions of the system have been recognized:

	Feet.
Hamilton limestone	60
Marcellus shale	20
Corniferous limestone	25
Onondaga limestone	30
Oriskany sandstone	200

All these divisions are highly fossiliferous, and some of them, notably the corniferous limestone, possess the dark color and fetid odor which usually characterize the oil and gas producing rocks. These beds thin out rapidly to the northward, and at the mouth of the Illinois river in Jersey county, the only representative of the entire series is about ten or twelve feet of Hamilton limestone, intercalated between the Niagara and the lower carboniferous series.

The next outcrop in a northerly direction is in Rock Island county, where the Hamilton limestone and shale is somewhat thicker, attaining a thickness above low water level of the Mississippi of fifty to sixty feet. On the eastern border of the State no outcrop of this formation is known, but it was penetrated with the diamond drill at Tuscola in their search for coal.

In LaSalle county the coal measures overlie unconformably the Trenton limestone, both the Devonian and Upper Silurian systems being absent, a phenomenon probably due to erosion anterior to the carboniferous period. The geographical extent of this erosion we have no data for determining at the present time, but no great thickness of Devonian strata have yet been revealed by the drill, either in central or northern Illinois, and, as the lower gas horizon, the Trenton limestone, has failed to yield it in notable quantity in any of the numerous borings made through it, the writer has not been disposed to encourage any considerable expenditure of capital in searching for natural gas in this State.

ARTESIAN WATER.

Three successful attempts to obtain artesian water have been made in western Illinois since the publication of Vol. VII, of these reports. Two of these are in Hancock county, one at the Riverside Sanitarium near Hamilton, which is located at the top of the bluff of the Mississippi river nearly opposite the city of Keokuk, and the other at Carthage on the prairie which forms the watershed between the Mississippi and the Illinois rivers.

The Hamilton well obtains its flow from the Niagara limestone which was reached by the drill at the depth of 680 feet. The flow from this well is estimated by Dr. Ringland, the proprietor of the Sanitarium, at 50,000 gallons per day, which I feel inclined to regard as an over-estimate. The water was said to rise in a rubber tube to the height of sixty-three feet above the surface.

The record of this boring describes the formations passed through as follows:

		Feet.
1.	Earth (soil, clay, etc)	25
2.	Limestone	100
3.	Flint	25
4.	Limestone	150
5.	White soapstone	125
6.	Blue soapstone	175
7.	Mostly flint	55
8.	Lime, sand and water	25
	Total depth	680

Nos. 2 and 3 are undoubtedly Keokuk limestone, No. 4 Burlington limestone, Nos. 5 and 6 Kinderhook shales, and Nos. 7 and 8 are Devonian and Upper Silurian limestones.

When the stratum from which the Hamilton flow comes was penetrated in the Carthage well, the water raised to within fifteen feet of the surface and remained there, indicating a difference in the surface level at the two localities of about 75 feet. This well was continued down to the depth of 975 feet, when, on reaching the St. Peters sandstone, a fine flow of water was obtained, but it failed to rise more than about five feet above the surface. Subsequently the boring was continued down to the Potsdam sandstone, without obtaining, however, any decided increase in the flow of water.

Unfortunately no accurate record of this well was kept, but the following data to the St. Peters sandstone was given me from memory by the foreman in charge of the work:

No.		Feet.
1.	Drift clay, sand and gravel	214
2.	White limestone	70
3.	Shale	355
4.	Limestone	336
5.	St. Peters sandstone	

No. 2 is undoubtedly the Burlington limestone, No. 3 includes the Kinderhook shales, the Devonian and Upper Silurian and the Cincinnati shales, and No. 4 the Trenton limestone.

The water from both these wells is so highly charged with mineral matter as to render it unfit for culinary use.

The third well was sunk tt Beardstown on the Illinois river and but a few feet above the flood plain of that stream. This well was undertaken in the expectation of finding natural gas in which the company were measurably successful, and the details of the record are given on a preceding page. The first flow of water, gas and oil was obtained soon after passing through the Kinderhook shales and in strata that are probably of Devonian age, but this was thought to be increased on passing through the Trenton limestone. The flow of water is estimated at 800 barrels per day, but no successful attempt has been made to measure the pressure of the gas. The production of oil is only about one-half gallon per day.

A boring at Monmouth in Warren county failed to obtain a flow of water, although carried down through the St. Peters sandstone, which at that locality was reached at the depth of 1,078 feet. The following record of this boring was furnished by Mr. J. H. Southwell of Rock Island.

No.		Feet.
1.	Drift clay	67
2.	Coal measure shale	5
3.	Burlington limestone	96
4.	Kinderhook shale	124
5.	Devonian shale and limestone	109
6.	Niagara limestone	68
7.	Cincinnati shale	83
8.	Trenton limestone	526
9.	St. Peters sandstone	154
	Total	1,232

No indications of natural gas or oil were observed in this well.

A boring was made at Jacksonville a few years since in search of coal, but as it commenced near the bottom of the coal measures, the prospect of a successful termination of the experiment was far from encouraging to any one conversant with the geology of Morgan county. This boring was carried to the depth of about a thousand feet, and I am indebted to Prof. H. E. Storrs for a copy of their record, which I have summarized as follows:

No.		Feet.
1.	Drift clay, &c	158
2.	Coal measures, with one coal seam	100
3.	Lower carboniferous limestone	433

4.	Kinderhook shale	222
5.	Devonian shale and limestone	19
6.	Niagara limestone	75
	Total depth	1,002

The boring now being prosecuted there in search of natural gas, is said to be down 1,600 feet, which, if true, would carry the drill into the sandstones below the Trenton limestone, and therefore quite through all known gas-producing horizons. The St. Peter's sandstone which was encountered at the depth of 1,055 feet at Beardstown, must be found within thirteen or fourteen hundred feet of the surface at Jacksonville, and below that sandstone neither gas or oil has been found as yet in the United States in sufficient quantity to render its exploitation a matter of practical importance.

PART II.

PALÆONTOLOGY OF ILLINOIS.

SECTION I.

DESCRIPTION OF FOSSIL INVERTEBRATES.

By A. H. Worthen.

ORDER ZOANTHARIA.

GENUS ZAPHRENTIS. Rafinesque.

ZAPHRENTIS DALEI. Edwards and Haime.

Zaphrentis spinulifera. Hall.

Pl. X, Figs. 12-12a.

This coral was described in the first Iowa report, Vol. 1, part 2, page 650. Pl. 22, figs. 1a, 1b. Its date is 1858.

In 1851 Edwards and Haime published a species which they named *Z. dalei* (Mon. d. Pol. Foss. d. Ter. Pal.) from the same locality, (Warsaw, Ill.,) which is probably the same as *Z. spinulifera*, in which case the specific name *dalei* should have precedence in accordance with the well established rules of nomenclature. Hall's description is given below.

"Coral in the form of a reversed cone, curved. Calyx slightly oblique, circular or sub-circular, the cavity deep; septal fossette strongly marked, situated on the inner side of the curvature. Radiating lamellæ strongly defined, somewhat irregularly curved, numbering at the margin from forty-two to fifty, and uniting in fascicles of two, three, four or more before reaching the center; outer walls of the calyx thin at the upper margins, becoming very thick and strong below. Externally somewhat rugose, and often swelling abruptly at intervals; the stages of growth marked by somewhat regular rows of nodes or short spines."

The following is a free translation of Edwards and Haime's description of *Z. dalei*, from the same locality: "Coral in the form of an elongated cone, moderately curved; external ridges irregular. Calyx oblique, sub-circular with a profound cavity. Fossette rather deep and situated on the side of least curvature. Lamellæ sixty to seventy, well developed, thin, alternately a little unequal, generally reaching to the center where they are a little curved, especially those adjacent to the septal fossette. Height 5 to 6 cent., diameter of the cup 2½ to 3 cent. Locality, Warsaw, Ill."

This description corresponds well with the form described subsequently as *Z. spinulifera*, the principal difference being in the larger number of lamellæ in E. and H.'s specimen. This character, however, is a variable one, and as there is no other form known from that locality that has even as many as fifty lamellæ, it becomes almost certain that their specimen was specifically identical with that subsequently described as *Z. spinulifera*.

The form from the Keokuk limestone that has usually been called *Z. dalei*, has only about 36 to 42 lamellæ, and agrees well with the form described by the above named authors under the name *Z. centralis*, to which I have no hesitation in referring it. The specimen figured on Pl. X, figs. 12–12a, belongs to the lower or Warsaw division of the St. Louis limestone, and was found by the writer at Warsaw, Ill.

No. 2556 of the Illinois State Museum.

ZAPHRENTIS CENTRALIS, Edw. and Haime.

Pl. IX, Figs. 1-1a. Pl. X, Figs. 13-13a.

Coral in the form of a curved cone, moderately elongated, without prominent transverse ridges; cup deep, circular; septal fossette large, central, and prolonged on the side of least curvature; lamellæ forty to forty-two, strongly developed and arranged usually in four groups.

Heighth of a mature specimen 3 inches; breadth of the cup 1½ inches. A smaller specimen measures 2⅛ inches in length, and breadth of cup 1⅛ inches.

Position and locality: Keokuk limestone, Warsaw and near Plymouth, Ill.

Collector, A. H. Worthen.

No. 2563 of the Illinois State Museum.

NOTE.—Edwards and Haime in their description of *Z. dalei*, do not mention the short spines that may be observed on specimens that have not been weathered, but these are often obliterated on specimens that have been long exposed to atmospheric influences.

ZAPHRENTIS SPINULOSA, Edw. and Haime.

Pl. X, Figs. 6-6a.

Coral turbinate, moderately elongated, a little curved and slightly distorted, with a few irregular external ridges; epitheca thin and on the lower portions ornamented with little sub-spiniform points; cup circular, moderately profound; fossette moderately developed, situated near the wall but in a variable position from conforming to the curvature; lamellæ about thirty, very feebly curved near the septal fossette, with an equal number of rudimentary lamellæ.

Height of an average size specimen, 1½ inches; breadth of cup, about ¾ to ⅞ inch.

Position and locality: Chester, Ill., Chester limestone.

Collector, A. H. Worthen.

No. 2559 of the Illinois State Museum.

ZAPHRENTIS CHESTERENSIS. (sp. nov.)

Pl. IX, Figs. 3-3a.

Corallum elongated, moderately curved, gradually and regularly tapering; calyx circular, not deep, fossette deep, and situated on the side of shortest curvature. Lamellæ in four divivisions, the two on either side of the fossette to the number of seven or eight coalesce before reaching the bottom of the calyx. On each side of the strong septum opposite the fossette, there are twelve or thirteen lamellæ that extend singly to the bottom of the cup. Surface slightly rugose, with traces of short spines scattered irregularly over it.

This is a variety of *Z. spinulosa*, E. and H., but may be readily distinguished by its more elongated and symmetrically tapering form, and greater number of lamellæ.

Height $2^{11}/_{16}$; diameter of calyx, 1¼ in.

Position and locality: Chester limestone, Monroe and Randolph counties.

Collector, A. H. Worthen.

No. 2560 of the Illinois State Museum.

ZAPHRENTIS PELLAENSIS. (sp. nov.)

Pl. IX, Figs. 6–6a and Pl. X, Fig. 11-11a.

Corallum turbinate, regularly curved, height of an average specimen 1⅜ in., diameter of calyx about ¾ in., depth of cup ⅜ in.; sides descending abruptly, the lamellæ on each side of the fossette to the number of four to six coalescing, while the others extend singly nearly to the center of the cup. Fossette narrow and situated obliquely to the curvature of the corallum. Whole number of the principal lamellæ 32 to 36 with about the same number in the secondary series. Surface moderately rugose and often marked by a few short scattering spines that are usually restricted to the lower portion of the corallum.

This form is closely related to *Z. spinulosa*, E. & H. from the Chester beds, but is usually shorter in proportion to its diameter, and coming from a different geological horizon it is entitled to be considered as a distinct variety.

Position and locality: St. Louis shales, near Pella, Iowa.

Collector, A. H. Worthen.

No. 2605 of the Illinois State Museum.

ZAPHRENTIS CALCARIFORMIS. Hall.

Pl. X, Figs. 2-2a.

This form was described in the Thirty-fifth Annual Report of the New York State Museum of Natural History, page 33, as a Devonian species, from the Falls of the Ohio. The following is the original description.

"Corallum simple, narrowly turbinate, regularly curved; diameter of calices in individuals of the same height varying from ten to fifteen millimeters; height twenty-five millimeters; exterior with frequent undulations and low rounded annulations; fossette narrow, very deep, commencing at the center and continuing to the posterior margin; the lamellæ extend to the margin; coalescing and forming vertical walls; number of lamellæ fifty, alternating in size; at a distance of two millimeters from the margin the smaller lamellæ coalesce with the others."

The specimen figured is an unusually long one, but presents the usual characters of the species.

Position and locality: Warsaw division of the St. Louis limestone, Coalsburg, Ky.

Collector, E. O. Ulrich.

No. 2558 of the Illinois State Museum.

ZAPHRENTIS CARINATUS (sp. nov.)

Pl. X, Figs. 3-3a.

Corallum curved, strongly compressed laterally; calyx deep, ovate; septal fossette extended on the side of least curvature. Primary lamellæ about thirty, with about the same number of very short secondary lamellæ intercalated between the primaries.

Length 1¼ inches; breadth of calice on its widest diameter ⅝ inch; opposite diameter of the same ½ inch; depth of calice ½ inch.

Position and locality: The specimen figured was obtained at Bentonsport, Iowa, and probably belongs to the Keokuk or St. Louis limestone, both of which outcrop in the vicinity.

Collector, A. H. Worthen.

No. 2564 of the Illinois State Museum.

ZAPHRENTIS CLIFFORDANA. Edw. and Haime.

Pl. X, Figs. 1,1a, 1b.

"Corallum in the form of a curved cone, external ridges not prominent, epitheca thin, making visible the ribs series of which are equal, plane and rather close. Calice circular and rather deep; fossette rather large and situated on the side of least curvature; lamellæ thirty-two to thirty-six, sub-equal, strong, a little thickened outwardly and thinning towards the interior, reaching generally to the center of the upper floor on which they are a little curved, and not elevated. Their free border appears to be cut obliquely. One distinguishing feature of the species is the equal number of rudimentary and primary lamellæ."

The above description applies very well to a common form of *Zaphrentis* in the Kinderhook beds of Illinois, and the specimens figured are from that horizon in Monroe county.

Collector A. H. Worthen.

No. 2570 of the Illinois State Museum.

ZAPHRENTIS ULRICHI, (sp. nov.)

Pl. X, Figs. 10-10a.

Corallum small, pointed, compressed and slightly curved; cup ovate, shallow; septal fossette comparatively wide, extending from the center to the margin of the cup on the side of least curvature.

Lamellæ fifty-two to fifty-four on the outer margin, but coalescing in pairs about one-third the distance from the margin to the center of the cup, so that only about twenty-six reach the central fossette.

Length of a medium size individual ⅞ inch; width of the cup across the greatest diameter ½ inch; in the opposite direction $^{6}/_{16}$ inch.

This species is closely related to *Z. calcariformis*, Hall, from the same horizon, (erroneously assigned by the author of the species to the Corniferous limestone,) but differs from that in its compressed, and more rapidly expanding form.

Position and locality: Warsaw division of the St. Louis limestone, Coalsburg, Ky.

Collector, E. O. Ulrich.

No. 2573 of the Illinois State Museum.

ZAPHRENTIS LANCEOLATUS. (sp. nov.)

Pl. X, Figs. 4-4a.

Corrallum small, pointed at the lower extremity, compressed, lanceolate, widening regularly from the pointed extremity to the upper margin of the cup; septal fossette well developed, and ranged in direction with the greatest diameter of the cup. Lamellæ twenty-two to twenty-four, all reaching to the border of the septal fossette.

Length of an average size specimen $^{13}/_{16}$ inch; breadth across the greatest diameter of the cup, $^{6}/_{16}$ inch; the broadest specimen seen measured in length $^{10}/_{16}$ inch; breadth of cup across its greatest diameter, $^{9}/_{16}$ inch; in the opposite direction, $^{5}/_{16}$ inch.

Position and locality: Warsaw beds of the St. Louis group, Spergen Hill, Indiana, and Coalsburg, Ky.

Collector, E. O. Ulrich.

No. 2572 of the Illinois State Museum.

ZAPHRENTIS ILLINOIENSIS. (sp. nov.)

Pl. IX, Figs. 4-4a.

Corrallum very broadly turbinate, cup oblique, surface marked by several transverse undulating ridges and numerous longitudinal striæ. Septal fossette deep and situated on the side of least curvature; lateral fossettes narrower but distinct, separating the lamellæ into three well marked divisions, the two on either side of the septal fossette consist of ten or eleven each, and the other of twenty-eight, making thirty-eight to forty primary lamellæ in the entire cup.

This species was evidently sessile, and was attached near the lower extremity to some cylindrical body, the scar of attachment being visible on nearly all the individuals seen.

Length of a large individual $2\frac{3}{8}$ inches; breadth of cup $2^1/_{16}$ inches; depth of the same about 1 inch.

Position and locality: Keokuk limestone, Warsaw, and near Plymouth, Hancock Co., Ill.

Collector, A. H. Worthen.

No. 2562 of the Illinois State Museum.

ZAPHRENTIS SPERGENENSIS. (sp. nov.)

Pl. X, Figs. 8-8a.

Corallum small, turbinate, straight or slightly curved at the lower extremity. Surface striated longitudinally, and characterized by numerous short spines irregularly distributed over the entire corallum. Cup circular and proportionally rather deep; septal fossette well defined, with a narrow lateral fossette on either side, separating the lamellæ into three divisions.

Primary lamellæ twenty-two, with about an equal number of a secondary order, the latter coalescing with the others at about half the distance from the border of the cup to the center. On each side of the septal fossette, and between that and the lateral fossettes, there are five primary and five secondary lamellæ, that coalesce into one before reaching the center of the cup.

Length of a medium size specimen $\frac{3}{4}$ inch; breadth of cup, $\frac{3}{8}$ inch; depth of the same, $^3/_{16}$ inch.

Position and locality: This little coral is common in the Warsaw beds at Spergen Hill, Indiana, and at Warsaw, Ill.

Collector, A. H. Worthen.

No. 2574 of the Illinois State Museum.

ZAPHRENTIS VARSOVIENSIS. (sp. nov.)

Pl. X, Figs. 9-9a.

Corallum small, turbinate, pointed below, and slightly curved; epitheca thin, external striæ distinct; height of corallum 1 inch; breadth of cup, $^7/_{16}$ inch; depth of the same, ¼ inch.

Septal fossette nearly central, and extended on the side of greatest curvature; primary lamellæ comparatively strong, and numbering about twenty-six, all reaching the thickened border of this septal fossette.

Position and locality: This symmetrical little species is quite common in the Keokuk limestone, at Warsaw, Hamilton, Nauvoo and Keokuk.

Collector, A. H. Worthen.

No. 2557 of the Illinois State Museum.

ZAPHRENTIS CYLINDRACEUS. (sp. nov.)

Pl. IX, Figs. 5-5a.

Corallum long, cylindrical, slightly curved, tapering at the lower extremity. Surface marked by numerous transverse undulations and fine longitudinal striæ. Cup shallow, the center slightly elevated as in the genus *Anisophyllum*. Septal fossette situated on the side of least curvature, and not reaching to the center of the cup. Lamellæ about thirty-two to thirty-four, which coalesce in several groups before reaching the central elevation.

Length, 2⅝ inches; breadth of cup ¾ inch.

Position and locality: Chester limestone, Chester, Ill.

Collector, A. H. Worthen.

No. 2561 of the Illinois State Museum.

ZAPHRENTIS REVERSA. (sp. nov.)

Coral very broadly turbinate, the length being but little more than the breadth of the cup; moderately curved, epitheca thin and interspersed with numerous rather stout spiniform points, irregularly distributed over the whole surface; cup nearly circular, moderately profound; fossette large and situated on the side of greatest curvature; lamellæ about forty-four, those on either side of the fossette to the number of about ten coalescing before reaching the center of the cup.

This species may be distinguished from the large allied forms by the size and position of the septal fossette.

Height, $1^{9}/_{16}$ inches; breadth of cup, $1\frac{1}{4}$ inches.

Position and locality: Warsaw division of the St. Louis group, near Columbia, Monroe Co., Ill.

Collector, A. H. Worthen.

No. 2567 of the Illinois State Museum.

Zaphrentis parasitica. (sp. nov.)

Pl. X, Figs. 5-5a.

Corallum small, truncated at the lower extremity, slightly expanded and compressed; breadth of the calice a little more than the length; surface marked with strong longitudinal striæ; septal fossette comparatively large, central, extending laterally on the side of greatest curvature; about twenty strong lamellæ extend from the border to the central fossette. Calice deep, and irregularly ovate in form.

Length $^{3}/_{16}$ inch; greatest breadth of calice about $\frac{1}{4}$ inch.

The specimen figured is parasitic on the ventral valve of *Productus pyxidatus.*

Position and locality: Kinderhook group: Clarksville, Mo.

Collector, A. H. Worthen.

No. 2571 of the Illinois State Museum.

Genus LOPHOPHYLLUM, Ed. & Haime.

Lophophyllum profundum. (sp. nov.)

Pl. X, Figs. 14-14a.

Corallum turbinate, straight or curved, tapering regularly to a pointed base; epitheca thin; surface marked by a few distinct encircling wrinkles, and numerous longitudinal striæ. Calice circular and deep, frequently occupying one-half the entire length of the corallum; columella prominent, pointed and lanceolate;

lamellæ about fifty, each alternate one comparatively robust, and extending to the bottom of the calice, while the others become obsolete before reaching the bottom.

Length of an average size specimen ⅞ inch; breadth of calice $^{9}/_{16}$; depth of the same $^{7}/_{16}$ inch.

Position and locality: Coal measures. Lower division of the LaSalle limestone, LaSalle, Ill.

Collector, A. H. Worthen.

No. 2565 of the Illinois State Museum.

GENUS ANISOPHYLLUM. Edwards & Haime.

ANISOPHYLLUM? IOVAENSIS. (sp. nov.)

Pl. IX, Fig. 7.

Corallum rather narrowly turbinate, slightly curved and pointed at the extremity. Central node prominent. No clearly defined septal fossett can be seen.

Lamellæ about thirty, three of which are elevated above the bottom of the cup, dividing it in four unequal divisions.

Height 1¼ inches; width of cup ½ inch; depth of the same ¼ inch.

I am not aware that any examples of the above named genus have hitherto been found in carboniferous strata, and hence refer the above described species to *Anisophyllum* with some doubt. It seems to be clearly distinct from *Zaphrentis*, and its affinities seem to be with the above named genus. In some respects it resembles the species described under the name *Zaphrentis cylindraceus*, from the Chester limestone, but differs from that in its shorter form, more elevated central node, and in the possession of three elevated lamellæ.

Position and locality. Calcareous shales of the St. Louis limestone, Pella, Iowa.

Collector, A. H. Worthen.

No. 2568 of the Illinois State Museum.

GENUS TRACHYPORA. Edw. & Haime.

TRACHYPORA AUSTINI. (n. sp.)

Pl. XI, Figs. 1-1a, 1b, 1c, 1d.

Corallum dendroid, the branches generally cylindrical, sometimes irregular, from 15 to 25 mm. in diameter, and infrequently divided. Corallites conical, diverging from an imaginary axial line to open on all parts of the free surface. The calices all oval or circular, very variable in size, the larger ones about 1.1 mm. in diameter, and either level with the general surface, or with an elevated margin. Each orifice is adorned with small tubercles or short ridges arranged in a radiate manner around the calice margin. Openings of the corallites separated by dense calcareous tissue, of variable thickness, but apparently always as wide as, or wider than the diameter of the tube orifices.

Sections show that the tubes are prismatic and in contact with each other, that their walls are greatly thickened by a calcareous deposit on the inner side of the tubes, and that the amount of the thickening increases toward the orifices. Mural pores of large size are present, but apparently not numerous. Tabulæ are best developed in the axial region, where they cross the tube cavity at intervals equalling once or twice the diameter of the tubes. Tangential sections show that the corallite cavities are surrounded by blunt, thick septal ridges. The walls are now composed of fibro-crystalline calcite, and the change has destroyed the finer details of structure.

In all important respects the species here described resembles the *Trachypora ornata*, Rominger sp., from the Hamilton gr. and I do not think any reasonable objection can be urged against placing them in the same genus. Specifically they are quite distinct, the corallum of Rominger's species being much smaller, the calices less variable in size and not so prominently margined, nor are the interspaces so thick.

Position and locality: Coal Measures. Labette Co., Kansas.

Collector, A. C. Austin.

No. 2596 of the Illinois State Museum.

Genus AMPLEXUS. Sowerby.

Amplexus geniculatus. (sp. nov.)

Pl. X, Figs. 7–7a.

Coral cylindrical above the geniculate portion and pointed below, and abruptly bent about half an inch above the lower extremity so as to form nearly a right angle with the upper part of the coral. Cup comparatively deep; lamellæ twenty-four or more; septal fossette not distinct on the specimens in hand; septa rather thicker than the intervening spaces.

Surface marked by a few undulating transverse ridges, and numerous longitudinal striæ.

Its geniculate character alone will serve to readily distinguish this species from any other known in the carboniferous rocks.

Position and locality: Chester limestone, Pope county, Ill.

Collector, A. H. Worthen.

No. 2566 of the Illinois State Museum.

PALÆOCRINOIDEA. Wachs. and Spr.

GENUS BATOCRINUS, Casseday.

BATOCRINUS MONTGOMERYENSIS. (sp. nov.)

Pl. XII, Figs. 2-2a.

Batocrinus montgomeryensis, Worthen, March, 1884. Bul'etin No. 2 of the Illinois State Museum of Natural History, page 25.

Body below the arms spreading into a saucer-like form, more than twice as wide as high, and composed of slightly convex granulose plates. Dome inflated, nearly twice as long as the body below,, and composed of nearly flat plates, each of which has a small obtusely pointed node in the center. Ventral tube central and apparently rather slender.

Basals short and forming a projecting rim around the columnar facet. First radial series 3×5; the first one hexagonal or heptagonal, nearly twice as wide as long. The second is quadrangular, about the same length as the first, and two-thirds as wide; the third wider than long, axillary, and supporting the first of the secondary series. The anterior ray has three secondary radials in each division. In the postero-lateral rays, the secondary radial series consists of five plates, three on one side and two on the other, the second plate on one side being an axillary plate which supports on each side the tertiary radials.

The antero-lateral rays have two series of secondary radials, consisting of two plates each, the upper one of which is axillary, and supports a double series of tertiary radials.

This gives an arm formula of two arms to the anterior ray, three each to the postero-lateral rays, and four each to the antero-laterals.

First anal plate as wide as long, heptagonal, supporting three plates above in the first series, five in the second, and three in the third, the middle one of the last series projecting about one-half its length above the others.

First interradial about as large as the first anal, and supports two smaller interradials above.

This species in its general form resembles *Batocrinus biturbinatus*, but the body is more spreading below the arms, the dome is more inflated, with flat nodose instead of convex plates. Arm openings directed upward.

Position and locality: Keokuk limestone, Montgomery county, Indiana.

Collection of A. H. Worthen.

BATOCRINUS SUBCONICUS. (sp. nov.)

Pl. XIII, Figs. 4-4a.

Batocrinus subconicus, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, p. 26.

There is another form occurring near the same horizon as the preceding, which resembles it somewhat in general form, but possesses characters that render it clearly distinct. The calyx is more expanded in proportion to its height than that of *B. montgomeryensis*, and is composed of flat instead of convex plates, with no projecting rim formed by the basal plates as in that species.

The dome is obtusely conical, composed of convex plates, and twice as long as the calyx below the arms, sloping up regularly and symmetrically into a rather stout, central ventral tube.

The calyx below the arms is nearly four times as wide as high, with the arm openings directed outward, and arm formula about the same as in *B. montgomeryensis*,. The specimen is so highly silicified that the form and number of the secondary and tertiary radials cannot be clearly determined.

Collection of A. H. Worthen.

BATOCRINUS UNIONENSIS. (sp. nov.)

Pl. XII, Figs. 5-5a, and Pl. XIII, Fig. 3.

Body depressed globose, width at the base of the arms a little greater than the height to the base of the ventral tube.

Plates of the calyx strongly beveled on their borders, leaving a deep suture between them on all sides.

Dome elevated, composed of plates that are elevated in the center, forming short and rather stout nodes.

Basal plates very small and concealed in the basal cup. First radials once and a half as wide as the second, and projecting so as to form a prominent rim around the basal cavity.

Second radials quadrangular, nearly twice as wide as long. Third radials pentagonal, axillary, and supporting on their upper sloping sides the secondary series.

The secondary and tertiary radial series, consist of three plates each, the last one of the third series giving support to the first arm plates.

First anal plate hexagonal, and succeeded by two smaller ones in a double series.

Arms composed of a double series of closely interlocking plates.

Ventral tube slender; column unknown.

Position and locality: St. Louis division of the Lower Carboniferous, Union county, Illinois.

No. 2581 of the Illinois State Museum.

BATOCRINUS NASHVILLÆ, Troost, sp.

Pl. XIII, Fig. 5.

This magnificent crinoid was described and figured in the Geology of Iowa, Vol. I, part 2, page 609, pl. XV, fig. 4, and pl. XVI, figs. 4, a & b, under the name *Actinocrinus nashvillæ* Troost; but none of the specimens known at that time had the remarkable ventral tube belonging to this species preserved, and an individual in which that organ is well preserved, is here illustrated.

The following is the original description of the species: "Body urn-shaped, rounded at base and excavated for the reception of the column, contracted above, and somewhat rapidly expanding at the brachial margin; dome moderately elevated, with a strong central proboscis. Basal plates more than twice as wide as long, spreading in a broad thickened rim, indented at the line of suture. First radial plates large, wider than long, tuberculose transversely, and prominent above the other plates. Second radials wider than long. Third radials supporting on the two upper oblique sides, two hexagonal supra-radial plates, and these support two brachial plates, from the upper sides of which proceed the arms, giving uniformly four arms to each ray. A small heptagonal intersupra-radial plate rests on the adjacent edges of the first supraradials.

First interradial plates heptagonal or octagonal; the anterior ones large, supporting two or three plates in the second and third range each. First anal plate as large as the first radials, strongly tuberculiform, supporting in the second range three plates, and in the third range four, with some small plates intercalated between the arms. Dome large, becoming proboscidiform. Surface granulose, the granules sometimes pustuliform.

Column large, consisting of strong joints separated by thinner ones, and, farther from the body, by two, three, four or more thinner ones."

In addition to the above description, I would add the following: Ventral tube long, gradually tapering and rising symmetrically from the center of the dome, composed of massive hexagonal plates, nearly all of which are produced into a short spiniferous node, and occasionally into a slender spine, half an inch or more in length. About half the length of the ventral tube above the dome a single row of six plates is replaced by stout spines ⅝ of an inch in length, and about $^5/_{16}$ inch in diameter at the base. These long spiniferous plates probably surround the anal opening. Above this the plates are less massive and diminish in size to the apex.

This fine species is only found in the Keokuk limestone, and for the use of the specimen figured I am indebted to Mr. L. A. Cox, of Keokuk, by whom it was kindly presented to the author.

GENUS POTERIOCRINUS, Miller.

POTERIOCRINUS SPINULIFERUS. (sp. nov.)

Pl. XIV, Fig. 3.

Poteriocrinus spinuliferus, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 27.

Body of medium size, short, width three times as great as the height to the top of the first radials; base depressed, underbasals small and concealed under the first columnar joint. Column obscurely pentagonal near its upper extremity, becoming round below, slender and composed of alternate thin and thicker joints near the base, beyond which it is unknown.

Basal plates forming a flat disk with slightly curving angles above and below, so that the body if detached would rest on the central portion of these plates. First radials short, pentagonal, twice as wide as high, angular below to fill the depressions between the basals. Under a good lens they show rude striations around their lower borders, with a slight depression in the upper margin, forming a well defined suture between them and the second radials. Second radial series on four of the rays as long as their greatest breadth below, angular in front, and compressed at the sides, the apex produced into a rather prominent node, and support on the upper angles the first divisions of the rays. The right antero-lateral ray divides again on the sixth plate, and again on the sixth and twelfth, while the left antero-lateral divides the second time on the sixth plate, and the outer division again on the seventh or eighth plate, while the inner one continues simple beyond the second bifurcation.

The anterior ray has five radial plates, the first corresponding in form and size with those of the other rays, the second is quadrangular; longer than wide, narrower above than below, the third and fourth are quadrangular, about half as long as wide, the fifth is about as long as wide, axillary and produced into a strong node like the axillary plates of the other rays.

The right division of this ray divides again on the tenth plate, while the left continues single as far as it is preserved.

All the axillary plates of the arms are nodose, and longer than the others, which are slightly wedge-formed and give off strong pinnules from their longer sides.

Position and locality: Chester limestone, near Columbia, Monroe county, Ill.

Collector, A. H. Worthen.

No. 2492 of the Illinois State Museum.

Poteriocrinus ulrichi. (sp: nov.)

Pl. XVII, Fig. 2.

Calyx below the second radial plates cup shaped, about twice as wide as high. Base concave, and underbasals concealed by the column. Basals on the posterior side pentangular slightly projecting on their upper margins, leaving a well defined suture between them and the second radials. The second radials are about twice as long as wide, strongly constricted in the middle and sharply angular above.

Arms two to each of the posterior rays, the only ones preserved in the specimen in hand, composed of long rounded joints, arranged in a somewhat zigzag position, and decreasing in length towards their extremities. Pinnules strong.

Anal plates arranged as usual in this genus, and united above to form a slender ventral tube, only the lower portion of which is visible.

Column round, composed of short pieces that decrease in diameter as the distance from the base increases.

Position and locality: Keokuk limestone, Keokuk, Iowa.

No. 337 of Mr. L. A. Cox's collection.

I take pleasure in dedicating this pretty species to my friend Mr. E. O. Ulrich of Newport, Ky.

POTERIOCRINUS ELSAHENSIS. (sp. nov.)

Pl. XIV, Fig. 5.

Calyx obconical, with straight gradually expanding sides. Base truncated, the under basals forming a shallow cup about three times as wide as high.

Basals large, the two on the anal side heptagonal, the others a little smaller and pentagonal or hexagonal.

First radials rather smaller than the basals, pentagonal, and excavated on their upper borders for the reception of the secondary radials.

Anal plates three, the first nearly as large as both the others, and situated as is usual in this genus, the first resting between the basals, the second resting on the summit of the left posterior radial, and the third on the summit of the first.

Secondary radials, arms and column unknown.

Position and locality: Kinderhook group near Elsah, Jersey county, Illinois.

Collector, A. H. Worthen.

No. 2580 of the Illinois State Museum.

POTERIOCRINUS NODOBASALIS. (sp. nov.)

Pl. XII, Figs. 3-3a, and Pl. XIII, Fig. 6.

Calyx short, forming a broad shallow cup below the brachial series. Under basals visible around the column where they form a small five-rayed star. Base depressed, basals prominent, and projecting below so as to form short transverse nodes. Radials short, twice as wide as long, pentagonal, and truncated squarely across their upper margins.

Brachials one to each ray, pentagonal, rather larger than the radials, wider than long and supporting on their upper angles the first arm plates.

On the left antero-lateral ray, both divisions bifurcate again, one division on the second, and the other on the fifth plate, beyond which they appear to be simple to their extremities.

Anal plates five visible, arranged as is usual in this genus.

Column composed of thin pieces, and pentagonal where it joins the body.

Position and locality: St. Louis limestone, Monroe county, Illinois.

Collector, Henry Tolbot, Esq.

No. 2577 of the Illinois State Museum.

POTERIOCRINUS BUFFALOENSIS. (sp. nov.)

Pl. XII, Fig. 1.

Calyx small, obconic below the summit of the radial plates, or about once and a half as wide as high. Basals small, pointed above, forming a low pentagonal cup.

Radials two on each of the two rays visible, the first pentagonal wider than high; the second quadrangular, and about twice as wide as high.

Brachials pentagonal, wider than high, pointed above, and supporting on their upper sloping sides the first arm plates.

Arm two to each of the rays visible, composed of rather stout joints that are longer than wide, and project slightly at their upper inner margins where they support stout pinnules.

Anal series unknown.

Column rather stout where it joins the body, composed of slightly projecting plates that diminish gradually in size below.

Position and locality: Devonian shales, Buffalo, Iowa.

Collection of A. H. Worthen.

POTERIOCRINUS ROWLEYI. (sp. nov.)

Pl. XIV, Fig. 9.

Calyx short, cup shaped, twice as wide as high, with a well defined suture between the radial and brachial series.

Brachials on the anterior ray two, a little longer than wide, the first quadrangular, and the second pentagonal, giving support on its upper angles to the first arm plates. These arms continue single after their first bifurcation.

The right antero-lateral and the left postero-lateral rays, have but one brachial each, which is pentagonal, length and breadth nearly equal, and gives support to the first division of the rays. These divisions bifurcate again on the fourth plate, giving four arms to each of these rays.

Arms stout for a species of this size, composed of joints about as wide as high, gradually tapering to their extremities. Anal side not visible.

Column round, and composed of alternately thick and thinner pieces, the former slightly projecting.

Position and locality: Chester limestone, Monroe county, Illinois.

Collector, A. H. Worthen.

No. 2575 of the Illinois State Museum.

Named in honor of Mr. R. R. Rowley, of Louisiana, Mo.

POTERIOCRINUS SPINULIFERUS. (sp. nov.)

Pl. XVII, Figs. 1-1a.

Body short, saucer shaped, about three times as wide as high, and composed of rather massive plates separated by well-defined sutures.

Base depressed, and under-basals concealed in the basal depression. Basals proportionally stout, pentagonal, the lower angles curving into the basal depression. Radials short and pentagonal, truncated squarely on their upper margins for the reception of the succeeding plates. Brachials one each to the posterior and antero-lateral rays, while the anterior ray has four. The first brachial on this ray is about as long as wide, quadrangular, and like thc corresponding plate on the other rays, is constricted, rounded on the outer surface, and succeeded by two short plates, the upper one giving support to a nodose axillary plate on which the first division of the ray takes place. In this ray the outer division bifurcates again on the tenth plate, but the inner continues single as far as it is preserved. The right antero-lateral ray bifurcates the second time on the sixth plate, and both divisions again on the sixth to the eleventh plate above, giving eight divisions to this ray. The left antero-lateral ray has its first bifurcation on the sixth plate, the inner division dividing again on the eighth plate, the outer one continuing single as far as it can be seen, giving but six divisions to this ray. The postero-lateral rays bifurcate in the same manner as the left antero-lateral ray, giving six divisions to each of these rays, and twenty-nine to the entire animal. The rays are composed of rather short, wedge-shaped pieces, that decrease very gradually in width towards their extremities.

Five anal plates are visible, the two lower ones resting apparently on one of the basals, an appearance that is probably due to the partial displacement of the body plates by pressure.

Column round or slightly pentagonal, and composed of alternate thin and thicker joints.

This crinoid has the general form of *Zeacrinus*, as defined by Wachsmuth and Springer, the only difference observable being the mode of bifurcation of the rays.

Position and locality: Chester limestone, Monroe county, Ill.

Collector, A. H. Worthen.

No. 2492 of the Illinois State Museum.

Poteriocrinus mammæformis. (sp. nov.)

Body small, obconic or mamillæform below the base of the arms and squarely truncated below where it is united with the column. Under-basals long and narrow, slightly angular at their summits, forming a little cup about once and a half as wide as high. Basals scarcely as long as the under-basals, but wider, probably hexagonal and heptagonal. Primary radials two, the first nearly quadrangular, about twice as wide as high, the second narrower, angular above, and supporting the first division of the rays.

Whether a second bifurcation takes place above this cannot be determined from the specimen in hand, but one arm is preserved to the ninth plate without division. Anal series unknown.

Column composed of thin circular plates, with a thicker one intercalated at intervals of six to eight plates below its summit.

The only example of this species we have seen is too much crushed for a complete diagnosis to be given, but its mamillate form, and long under-basals, will serve to distinguish it from any species known from this horizon.

Position and locality: Warsaw beds of the St. Louis formation, Warsaw, Illinois.

Collector, A. H. Worthen.

No. 2578 of the Illinois State Museum.

GENUS CALCEOCRINUS. Hall.

CALCEOCRINUS ROBUSTUS. (sp. nov.)

Pl. XII, Fig. 7.

Calyx subquadrate with the upper lateral angles truncated and sides constricted. Basal plate triangular, about three times as wide as high. Lower dorsal plate triangular, of about the same width as the basal, and beveled below to fit the basal plate. Dorso-lateral pieces twice as wide as high, with the upper inner angles truncated for the reception of the succeeding plate. Upper dorsal plate triangular, about once and a half as wide as high, and slightly rounded at the lateral angles.

Dorsal arm robust, composed of six stout first radial plates, the upper of which is axillary, giving support to the secondary series of which there are three, the upper one an axillary plate supporting the arms. The outer division continues single while the inner one divides on the third or fourth plate, giving six arms to this ray.

Lateral rays five, four of which are nearly equal in size, the fifth quite small, and not preserved beyond the first bifurcation. The first radial plate in the lateral rays is twice as long as wide, that of the first lateral resting obliquely on the excavated outer angle of the dorso-lateral pieces. This is succeeded by a series of radials so thoroughly anchylosed that the exact number cannot be determined, two of which are protuberant, including the axillary plate. One division of the ray probably divides again, but the other remains single to its extremity.

Column round, comparatively rather stout, and composed of slightly projecting pieces.

The specimen is silicious, and the surface markings, if any existed, are thus obscured.

Position and locality: Keokuk limestone, Keokuk, Iowa.

Collection of Mr. L. A. Cox.

CALCEOCRINUS TUNICATUS, Hall, sp.

Pl. XII, Fig. 6.

Calyx less massive than in the preceding species, basal plate triangular, and about twice as wide as high. Lower dorsal plate short, or about three times as wide as high. Dorso-lateral plate six-sided, with a strong constriction on ther outer lateral borders, and their inner angles truncated above for the reception of the upper dorsal plate. This plate is triangular, about twice as wide as high, and slightly protuberant. The three first plates of the dorsal ray are shorter than the six succeeding ones, which are a little wider than long, and slightly protuberant. The ninth plate is axillary, and supports the arms, which appear to be simple to their extremities.

Lateral rays five, of which only four are well preserved. First radial series in these rays eight, including the long narrow series that is arranged somewhat obliquely around the lateral sides of the calyx. One or two of these in each ray, including the axillary plate, are protuberant. Arms single above the first division on all the rays visible.

We refer this form to the species described in the Thirteenth Report to the Regents of the N. Y. University, under the name of *Cheirocrinus tunicatus*.

Position and locality: Keokuk limestone, Keokuk, Iowa.

Collection of Mr. L. A. Cox.

Genus AGARICOCRINUS. Troost.

Agaricocrinus nodulosus. (sp. nov.)

Pl. XIII, Figs. 1-1a.

Calyx of medium size, base deeply depressed, the basal depression including the basals, first radials, and the lower part of the second radial plates. All the plates in the basal depression are smoother, and all above are strongly nodose. This species has a tertiary series of radials, smaller than the secondary, giving support to the first arm plates, which are also nodose.

Dome pyramidal, with a series of large, strongly nodose, plates immediately above the arm bases, the number of which is determined by the number of arms in the ray. When the ray has four arms, there are three of these plates, two immediately above the base of the arms, and the third above and partly between those below. When the ray has three arms, there are two of these plates, and over the anterior ray, which has but two arms, there is only a single large plate. These plates are succeeded by about three rows of smaller plates, that extend up to the large apical plate which crowns the summit. Anal opening small, and situated just below the apical plate. The anterior ray has two arms, the right anterior and two posterior rays four each, and the left anterior three, making seventeen altogether, which is probably an abnormal number.

This species may be distinguished from *A. americanus*, by its tertiary radials, and by the strongly nodose character of all the plates of the calyx, except those included in the basal depression.

Position and locality: Keokuk limestone, Keokuk, Iowa.

Collector, Mr. L. A. Cox.

Collection of A. H. Worthen.

Agaricocrinus macadamsi. (sp. nov.)

Pl. XIII, Figs. 2-2a.

Calyx large, strongly inflated above the arms, and depressed below, the basal depression including the entire basal and radial series.

Basals and first radials smooth, second radials and succeeding arm plates slightly nodose.

The anterior and left anterior rays have three arms each, and the right anterior and the two posterior rays four each, making altogether eighteen arms, which is probably the normal number.

Immediately above the arm openings there are from three to four rather large nodose plates, while those forming the upper part of the dome are smooth or but slightly elevated in the center.

Anal area large, protuberant, and composed of twenty-four or more nearly smooth plates, above which the anal opening is situated.

The basal and radial plates are obscured by cherty material, so that their relative size and form cannot be determined.

We dedicate this fine species to the Hon. Wm. McAdams, of Alton, by whom it was found.

Position and locality: Keokuk limestone, Jersey county, Illinois.

Collection of A. H. Worthen.

GENUS CENTROCRINUS. Wachsm. and Spr.

CENTROCRINUS TENNESSEENSIS. (sp. nov.)

Pl. XIV, Fig. 1.

Calyx broadly turbinate, breadth at the base of the arms equal to once and a half its height.

The basal plates form a low pentagonal cup, about twice as wide as high, with projecting lower borders, which form a rim around the columnar facet.

The first radial plate is as large or larger than the second and third combined, and has seven distinct angles.

Second radials quadrangular, about twice as wide as long; third radials about the same size as the second, axillary, and supporting the succeeding radial series, which in rays visible on our specimen consists of a single axillary plate, giving four arms to each ray.

One long oval plate fills each of the interradial spaces on the free side of the specimen in hand.

The arms are not preserved beyond the fifth or sixth joint, and the fifth plate on one arm seems to be an axillary plate, and possibly a second division takes place in all the arms in perfect individuals. Arms as far as can be seen, composed of short quadrangular joints, about twice as wide as long.

Column round, and composed of alternately thick and thinner joints, the former slightly projecting.

Position and locality: Niagara limestone, near Clifton, Wayne county, Tennessee.

Collection of A. H. Worthen.

GENUS AMPHORACRINUS. Austin.

AMPHORACRINUS JERSEYENSIS. (sp. nov.)

Pl. XIV, Figs. 8-8a.

Calyx short, the radial series spreading laterally so as to form a low shallow cup, more than three times as wide as the height to the base of the arms. The basal plates project slightly below, so as to form a rim around the columnar facet.

The specimen in hand has an abnormal structure, the anterior ray being obsolete. The right posterior and the left anterior divisions of the calyx have the normal number of three radials to each ray; while the left posterior and the right anterior divisions have but two radials each, the second being as large or larger than the first and supporting the first arm plates.

Anal plates three, the first hexagonal, the second smaller and quadrangular, resting upon the first, with two larger anals on either side which rest partly on the lateral sides of the first radials, and partly on the first anal plate. Above these four anals, there are six slightly protuberant plates arranged around a small anal opening.

In the normal divisions of the calyx there is a single large interradial plate.

On the anterior side there are four plates rather larger than the first four on the anal side, and arranged in the same manner.

Summit composed of numerous nodose plates, a massive one crowning the summit, as in some species of *Agaricocrinus*.

The specimen has six arms, one each to the posterior, and two each to the antero-lateral rays.

Position and locality: Kinderhook group, Jersey county.

Collector, A. H. Worthen.

No. 2582 of the Illinois State Museum.

Genus ACTINOCRINUS. Miller.

Actinocrinus lobatus. Hall.

Pl. XII, Figs. 8-8a.

Body large, urn-shaped below the arms, and conical above, the dome gradually diminishing into a strong ventral tube composed of strongly protuberant plates.

Basal plates nearly as large as the first radials, thickened below so as to form a slightly projecting rim around the column.

First radials large, length and breadth nearly equal, hexagonal and heptagonal; second radials about half as large as the first, and hexagonal; third radials smaller than the second, giving support to two brachials. These are succeeded by a second and third series of small brachials of which there are four or more to each ray.

First interradial hexagonal, about the same size as the second radial, succeeded by two smaller interradials, with a third and fourth series of still smaller interradials of three each.

First anal plate smaller than the first radials, hexagonal with two smaller hexagonal plates in the second series, three in the third series, and four in the fourth.

Surface of the plates traversed by ridges, which, joining together near the center of the plates, form short flattened nodes.

Arms composed of a double series of short interlocking plates, and, on one of the specimens figured, showing numerous bifurcations.

Position and locality: Keokuk limestone, Greene county, Ill.

Collector, Henry Talbot, Esq.

No. 2583 of the Illinois State Museum.

Genus EUPACHYCRINUS. Meek and Worthen.

Eupachycrinus orbicularis. Hall sp.

Pl. XIV, Figs. 2-2a.

This species was described in 1860, in the Boston Journal of Natural History as *Scaphiocrinus orbicularis*. The following is the original description:

"Body below the arms very broadly basin-shaped, or depressed hemispheric, with the upper margins inflected; articular scar for the column attachment sharply impressed, extending one-half or two-thirds the diameter of the basal plates.

Basal plates pentagonal, obtusely angular above, forming by their union a pentagon with scarcely concave margins. Sub-radial plates exceedingly large, extending from the edge of the column to near the top of the first radial plates, three sub-pentagonal and two heptagonal (or hexagonal from the straightness of the lower sides), length somewhat greater than breadth. First radial plates proportionally small, sub-triangular; the lateral edges of the adjacent plates slightly truncating each other. First anal plate large and massive, pentagonal, resting between the two heptagonal sub-radials, and supporting one side of the adjoining first radial plate. The two remaining anal plates, (all of which are seen in the specimen,) are smaller and hexagonal.

Arms and column unknown. Surface of plates depressed convex, sutures distinctly marked. The body plates are very massive, the internal cavity being less than half the whole diameter."

Position and locality: Keokuk limestone, Keokuk, Iowa.

The specimen figured is in the collection of A. H. Worthen.

EUPACHYCRINUS? SANCTI-LUDOVICI. (sp. nov.)

We have obtained from the St. Louis quarries some crushed specimens of a form apparently belonging to the above named genus, none of which are quite well enough preserved to admit of a clear and full diagnosis, but differing so much from all other crinoidal forms known from this horizon, that the crushed specimens may be easily recognized when the general form is known.

Body of medium size, basin-shaped, base depressed, the under-basals concealed in the basal concavity. Basals prominent, the lower angles curving upward into the basal depression, their upper angles extending nearly to the summit of the first radial plates. First radials pentagonal, their lower angles fitting into the depression between the basals, widest at their summits where they are squarely truncated for the support of the second radials. Brachials as long as wide at bottom, constricted in the middle, and supporting the first division of the rays. These plates are all prominent in the center or sub-nodose, the axillary plates more so than the plates below.

Some of the rays after their first division on the second radial divide once or twice more on the fifth and sixth plate, and possibly all may do so, though that cannot be determined from the specimen at hand.

Anal plates and column unknown.

Position and locality: St. Louis limestone, St. Louis, Mo.

Collector, A. H. Worthen.

No. 2579 of the Illinois State Museum.

GENUS BARYCRINUS, Wachsmuth.

BARYCRINUS SPURIUS. Hall. sp.

Pl. XIV, Fig. 4.

Calyx broad basin-shaped, composed of massive depressed convex plates. Under-basals spreading horizontally beyond the columnar facet form a pentagonal disc. Basals hexagonal counting three angles on their lower margins, except the one on the anal side which is heptagonal.

First radial plates wide, the antero-lateral ones longer than the others; second radials very short; third radial somewhat longer, and both nearly as wide as the first. The third radial is angular above, and gives support to two stout arms, composed of massive plates about as long as the second radials.

First anal plate as large as the anterior basals, and hexagonal counting three angles on the lower margin. In the typical specimen figured in the Geology of Iowa, Vol. 1, part 2, plate 18 figs. 7 and 8, there is a small quadrangular anal plate intercalated between the large first anal and the right posterior basal, but this seems to have been an abnormal character not usually observed in this species.

This specimen has been figured to show the character and arrangement of the arms.

Position and locality: Keokuk limestone, Warsaw, Illinois.

Collection of A. H. Worthen.

BARYCRINUS TUMIDUS. Hall. sp.

Pl XIV, Fig. 6.

Cyathocrinus tumidus Hall. Geology of Iowa, Vol. 1, part 2, page 624. Pl. XVIII, Figs. 1, a. b.

"Calyx basin form, shallow, the plates thick and tumid. Basal plates small; their area nearly occupied by the column, and presenting a small pentapetalous opening in the center. Subradial plates with the bases nearly straight, pentagonal, except the one on the anal side which is hexagonal; each plate prominently convex or tumid. Radial plates somewhat unequal, very thick and broad, convex in the middle; articulating faces nearly in a plane with the axis. First anal plate quadrangular, small.

Surface finely granulose or granulose-striate towards the margins of the plates.

The base is more prominent than the surrounding subradial plates; in which character it differs from *C. bullatus*, the subradials being less prominent, and the radials larger and more equal in size."

The above is the original description of this species, the type specimen consisting of the calyx only. In the figured specimen on Pl. XIV, the arm formula is clearly shown. On three of the rays, to-wit, the anterior and the posterior laterals, there are two brachials, the first one very short and nearly as wide as the radials, the second a little longer, obtusely angular above, and giving support to the two divisions of these rays. On the other rays there are no brachials, each sustaining a single arm supported on the upper surface of the radial plates, giving eight arms to each individual. Arms composed of massive plates, decreasing very gradually in breadth from their base upwards.

Position and locality: Keokuk limestone near Hamilton, Hancock county, Illinois.

Collection of A. H. Worthen.

GENUS DORYCRINUS. Rœmer.

DORYCRINUS MISSISSIPPIENSIS. Roemer.

Pl. XII, Fig. 4,

Body broadly urn-shaped, dome convex, with six long slender spines, five of which are situated immedialy above the summit of the rays, while the sixth crowns the summit of the dome. These spines are sometimes bifurcated as seen in the example figured.

Basal plates massive, spreading at their lower margins and separated by clearly defined sutures. First radial plates hexagonal, about twice as wide as long. The left antero-lateral ray in the specimen figured has but two radials, the second of which is an axillary plate, supporting on its upper sides two secondary radials. In the other rays there are three radials, the second of which is quandrangular in outline, the third pentagonal, and gives support to two pentagonal secondary radials. These are succeeded by four tertiary radials that support the arms, the normal number of which is four to each ray. The plates forming the dome are more convex than those below the arms.

Interradial plates three visible below the arms, the first large, and heptagonal, the other two smaller and hexagonal. First anal plate heptagonal, length and breadth nearly equal, and supporting three smaller anals in the second series.

Column round and consisting near the summit of alternating thicker and thinner joints, the latter increasing in number as the distance from the body increases.

Position and locality: Keokuk limestone, Hamilton, Illinois.

This magnificent specimen was collected by Mr. L. A. Cox, by whom it was presented to the author.

Collection of A. H. Worthen.

BRACHIOPODA.

GENUS DISCINA. Lamarck.

DISCINA VARSOVIENSIS. Worthen.

Pl. XI, Fig. 7.

Discina varsoviensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 23.

Shell of medium size, ovate in outline, anterior and posterior margins nearly equal in width. The larger or free valve is crushed so that its general form cannot be clearly determined; its surface, however, is ornamented around the borders with ten to twelve or more rather strong and sharp concentric ridges, which become less conspicuous or obsolete towards the apex.

The lower valve is nearly flat and marked around the border by fine concentric ridges rather less conspicuous than those on the other valve, with a long narrow slit or foramen extending from about the center of the valve more than half way to the posterior extremity, and surrounded by an elevated margin.

Length of an average size lower valve ¾ inch; greatest breadth of the same $^{10}/_{16}$ inch.

Position and locality: Keokuk limestone, Warsaw, Ill.

Collector, A. H. Worthen.

No. 2545 of the Illinois State Museum.

GENUS TEREBRATULA. Llwyd.

TEREBRATULA ROWLEYI. Worthen.

Pl. XI, Figs. 6, 6a, 6b.

Terebratula rowleyi, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 23.

Shell below the medium size, inequivalve, conical; ventral valve strongly convex in the middle from the beak to the basal margin, and rapidly sloping on either side to the lateral borders.

Beak of the ventral valve pointed, slightly recurved, and extending beyond that of the opposite valve; both valves longer than broad and sinuate in front. Dorsal valve slightly convex at the umbo, where a shallow depression commences and widens downward, and at the front occupies nearly the entire width of the valve. Surface smooth or showing only very fine lines of growth.

Length of ventral valve from beak to base $^7/_{16}$ inch; greatest breadth $^6/_{16}$ inch; thickness of the shell with the valves united about one-third the length from the beak to the front, ¼ inch.

Position and locality: From a cherty bed near the base of the Burlington limestone, Pike county, Mo.

Collector, R. R. Rowley.

No. 2526 of the Illinois State Museum.

GENUS ATHYRIS. McCoy.

ATHYRIS SQUAMOSA. Worthen.

Pl. XI, Fig. 2.

Athyris squamosus, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 24.

Shell of medium size, broadly ovate transversely, or nearly circular in outline; valves depressed, and showing externally five heavy imbricating or overlapping plates, that were covered originally with short, coarse spines. Beaks depressed and closely approximate, that of the ventral valve rather the most prominent, and projecting beyond the other, with a perforated extremity.

Length from beak to base $^{10}/_{16}$ inch; greatest width of the valves $^{11}/_{16}$ inch; thickness about $^5/_{16}$ inch. This unique form differs so strongly from all others in the Carboniferous formation that a comparison is unnecessary.

Position and locality: Oolitic beds of the St. Louis limestone, Monroe county, Ill.

Collector A. H. Worthen.

No. 2527 of the Illinois State Museum.

GENUS RHYNCHONELLA. Fischer.

RHYNCHONELLA ILLINOIENSIS. Worthen.

Pl. XI, Figs. 3-3a, 3b, 3c.

Rhynchonella illinoiensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 24.

Shell of about medium size, transversely ovate to sub-circular, wider than long, front nearly straight in the middle, beaks obtusely pointed. Ventral valve slightly elevated near the beak, and depressed towards the front into a broad, shallow mesial sinus, which is occupied by about eight sub-angular plications that interlock in front with those of the opposite valve. There are also from eight to ten similar plications on each side of the sinus.

Dorsal valve sharply depressed at the sides, nearly flat from the beak to the front, which is elevated into a broad mesial fold on which there are about eight elevated plications that interlock with those of the opposite valve, and about the same number on each side of the mesial fold. Length of an average size specimen $^{6}/_{16}$ inch; width ½ inch; thickness in front about equal to the length. The small individuals of this species, if found in Upper Silurian strata, might be mistaken for *R. wilsoni*.

Position and locality: Coal Measures, Peoria county, Ill.

Collector, Mr. Gifford and W. H. Adams.

No. 2537 of the Illinois State Museum.

GENUS LINGULA. Bruguière.

LINGULA VARSOVIENSIS. Worthen.

Pl. XI, Fig. 8.

Lingula varsoviensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 24.

Shell of medium size, longitudinally oblong, more than one-third longer than wide, with sub-parallel sides, the broadest part being a little below the middle of the shell.

Basal margin broadly rounded, beak rather prominent, anterior margin more narrowly rounded than the basal, but not quite perfect in the specimen in hand.

Surface ornamented with numerous concentric striæ, or fine lines of growth that are most conspicuous on the borders of the shell.

Length $^{15}/_{16}$ inch; greatest breadth $^{9}/_{16}$ inch.

This species resembles in its general form the *L. mytiloides* of the Coal Measures, but differs from that in its uniformly much larger size and relative proportions.

Rare, and hitherto found only in the Warsaw beds of the St. Louis group at Warsaw and near Hamilton, Ill.

Collector, A. H. Worthen.

No. 2495 of the Illinois State Museum.

GENUS SPIRIFERA. Sowerby.

SPIRIFERA MULTIGRANOSA. (sp. nov.)

Pl. XI, Figs. 5-5a, 5b.

Shell of medium size, ventral valve strongly convex, length a little more than the width; hinge line about equal in length to the greatest width of the valve. Beak strongly arched, and recurved beyond the cardinal area.

A profound sinus commences at the beak, and gradually widens and deepens to the frontal border where it occupies about one-third of the entire width of the valve. There are two rather obscure costæ on each side of the sinus, one of which extends nearly to the beak, while the other becomes obsolete about half way from the frontal margin to the beak. On each side of the sinus there are from 8 to 10 unequal sized rounded plications that are wider than the intervening spaces. Cardinal area moderately wide.

Dorsal valve less convex than the ventral, beak depressed, incurved, and not projecting beyond the hinge line, area narrow. A strong mesial fold commences at the beak with a rather broad flat costa, having a central depression that continues to the frontal margin. On each side of this there is an obscure costa, that becomes obsolete before reaching the beak. The two first plications on each side of the mesial fold are much stronger than those on the lateral borders. The entire surface of the shell is thickly set with small granules, Position and locality: Coal measures, Rolls Ford, Sangamon county.

Collector, A. H. Worthen.

No. 2597 of the Illinois State Museum.

Genus ORTHIS. Dalman.

Orthis resupinoides. Cox.

Pl. XI, Figs. 4-4a, 4b.

Shell transversely ovate to subquadrate in outline, hinge line straight, and scarcely more than half as long as the greatest breadth of the shell; cardinal angles rounded, cardinal area narrow, and widest on the dorsal valve.

Dorsal valve depressed, convex towards the beak, and strongly depressed at the front, giving a sinuous outline to the frontal margin.

Ventral valve convex, the greatest convexity rather nearer the beak than the front. Beaks depressed, incurved, and projecting slightly beyond the hinge line.

Surface of the valves marked by numerous fine thread-like striæ, and several transverse lines of growth.

This shell is so closely allied to Martin's species, *O. resupinata*, that it can hardly be regarded as specifically distinct. The only external differences observable, on a comparison of the American with authentic examples of the European shell are, the comparatively shorter hinge line and somewhat finer striæ of the American shell.

Position and locality: Lower Coal Measures, Mercer county, Illinois.

Collector, Tyler McWhorter, Esq.

No. 2600 of the Illinois State Museum.

LAMELLIBRANCHIATA.

GENUS LEPTODOMUS. McCoy.

LEPTODOMUS? MAGNUS. Worthen.

Pl. XVIII, Fig. 2.

Schizodus magnus, Worthen, March, 1884, Bulletin No. 2, of the Illinois State Museum of Natural History, page 9.

Shell large. ovate sub-quadrangular, convex, the greatest convexity being about half-way from the beaks to the ventral margin; anterior extremity comparatively long and broadly rounded, posterior side about once and a half the length of the anterior, obliquely flattened behind the beaks with a well defined umbonal ridge extending diagonally from the beak to the posterior extremity of the ventral margin. Dorsal margin straight from the beaks to the obliquely truncated posterior margin.

Beaks long, strongly recurved, and projecting about $\frac{3}{8}$ of an inch beyond the dorsal margin.

Length $^{7}/_{16}$ inches; height $2^{6}/_{16}$ inches; convexity of the valve about $\frac{1}{2}$ inch.

This is from one of the upper divisions of the Chester limestone, about two miles below the mouth of Mary's river, Randolph county; Ill.

Collector, A. H. Worthen.

No. 2498 of the Illinois State Museum.

GENUS SCHIZODUS. King.

SCHIZODUS VARSOVIENSIS. Worthen.

Pl. XIX, Fig. 7.

Schizodus varsoviensis, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 10.

Shell of medium size, transversely ovate, moderately convex in the anterior and umbonal regions, cuneate posteriorly; anterior side very short and regularly rounded; basal margin forming a very gentle curve that is most prominent near the anterior margin; posterior extremity contracted and narrowly rounded; dorsal margin nearly straight, beaks depressed, incurved and located about one-third the length of the shell from the anterior margin. Surface markings unknown.

Length of an internal cast in limestone 1⅛ inches; height of same ⅞ inch, convexity about ⅝ inch.

This species may be readily distinguished from *S. chesterensis*, which it approaches in size and form, by its relative proportions and more depressed beaks.

Position and locality: The upper part of the Keokuk limestone, Warsaw, Ill.

Collector, A. H. Worthen.

No. 2500 of the Illinois State Museum.

SCHIZODUS NAUVOOENSIS. Worthen.

Pl. XX, Fig. 3.

Schizodus nauvooensis, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 10.

This shell is only known from a cast of a single valve in limestone, but it differs so decidedly from all others of this genus, that it may be readily characterized as follows:

Shell above the medium size, obliquely sub-ovate, rather strongly convex from the beak obliquely downward for about half the length of the valve, and thence gradually depressed to the ventral margin, anterior extremity regularly rounded from the dorsal to the ventral margin, posterior side oblique, the marginal line curving in below the beak; ventral margin not entire, beak pointed, elevated and incurved, and situated near the anterior margin, surface markings unknown. A well-defined ovate muscular scar is conspicuous just below the beak, and near the anterior border of the shell.

Length from the beak to the ventral margin measuring obliquely, 2 inches; greatest breadth 1⅜ inches.

Position and locality: Keokuk limestone, Nauvoo, Ill.

Collector, A. H. Worthen.

No. 2499 of the Illinois State Museum.

SCHIZODUS DEPRESSUS. Worthen.

Pl. XVIII, Figs. 8-8a.

Schizodus depressus, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 11.

Shell below the medium size, transversely ovate, slightly convex, beak depressed, posterior extremity cuneate, anterior extremity regularly rounded into the semi-ovate curve of the basal region. Posterior side a little longer than the anterior, and rather sharply rounded at the extremity; dorsal margin rapidly sloping towards the anterior extremity; surface smooth.

Length of an average size specimen $^9/_{16}$ inch; height from beak to basal margin $^7/_{16}$ inch; convexity of the valves about $\frac{1}{8}$ inch.

This species may be readily distinguished from all previously described species by its generally depressed form.

Position and locality: Oolitic beds of the St. Louis group, Monroe county, Ill.

Collector, A. H. Worthen.

No. 2520 of the Illinois State Museum.

SCHIZODUS? CIRCULUS. Worthen.

Pl. XIX, Fig. 1.

Schizodus? circulus, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 11.

In the collection from the oolitic beds of Monroe county, there are three or four detached valves of a small shell, that are doubtfully referred to the genus *Schizodus*, and which may be characterized as follows:

Shell small, nearly circular in outline, slightly inequilateral, valves slightly convex, beaks depressed, and extending slightly beyond the cardinal border. A very slight umbonal ridge is apparent on some of the specimens that becomes obsolete before reaching the basal margin. Surface smooth. Height from beak to base $^7/_{16}$ inch; length $\frac{1}{2}$ inch.

This shell resembles the form figured and described by Prof. McCoy in his "Synopsis of the Carb. Fossils of Ireland," Pl. XI, fig. 13, but is much more nearly circular than his *Dolabra orbicularis*.

Position and locality: Oolitic beds of the St. Louis group, Monroe county, Ill.

Collector, A. H. Worthen.

No. 2521 of the Illinois State Museum.

SCHIZODUS ULRICHI. (sp. nov.)

Pl. XXI, Figs. 1-1a, 1b. Pl. XX, Fig. 9.

Shell above a medium size, ovate, valves moderately compressed; beaks strongly incurved forward, and situated a little less than one-half the length of the shell from the anterior margin. Anterior border evenly rounded up from the basal margin to the beaks. Hinge line short; basal margin rather long, and gently curving behind to the rather narrow posterior extremity. Lunule clearly defined, but not deep. A slightly elevated umbonal ridge extends from the beaks to the posterior extremity. Surface smooth except some faint lines of growth near the basal margin.

Anterior adductor muscular scar nearly circular, and situated about half way from the beak to the base of the anterior margin; posterior muscular scar not so well defined, and situated about equi-distant from the beaks to the posterior extremity.

Length of a specimen of average size, $1^9/_{16}$ inches; breadth from the beaks to the cardinal border $1\frac{1}{2}$ inches; thickness with the valves united 1 inch.

This shell has been confounded with *S. wheeleri*, Swallow sp. but differs from that shell as usually figured in its larger size, depressed umbonal slopes and ovate outline.

Position and locality: Upper Coal Measures, Fairfield, Wayne county, Illinois.

No. 2584 of the Illinois State Museum.

SCHIZODUS RANDOLPHENSIS. (sp. nov.)

Pl. XX, Fig. 12.

Shell elongate ovate, truncated at the anterior extremity and narrowly rounded behind. Beak depressed, projecting beyond the hinge line, and situated close to the anterior extremity.

Hinge line about two-thirds as long as the valve with a wide cardinal area nearly equaling it in length. Basal area regularly curved from the truncated anterior margin to the posterior extremity.

Anterior muscular scar, situated close to the anterior extremity, and about midway from the beak to the basal margin. Dorsal scar about twice as large as the anterior one, and located midway between the beak and the posterior extremity. Surface markings unknown.

Length 2⅛ inches; height about $1^{3}/_{16}$ inches.

Position and locality: Chester limestone, Chester, Ill.

Collector, A. H. Worthen.

No. 2590 of the Illinois State Museum.

GENUS PINNA, Linnæus.

PINNA SANCTI-LUDOVICI. Worthen.

Pl. XIX, Fig. 6.

Pinna St. Ludovici Worthen, 1883. Geol. Survey of Illinois, Vol. VII, page 326.

Shell comparatively short, lanceolate; length about twice as much as the greatest width. Section ovate-elliptical, valves traversed longitudinally by about twelve to fifteen rather strong ribs that are most prominent on the middle portion of the shell, and become obsolete towards the ventral and dorsal margins. Spaces between the ribs narrow, beak unknown. Angle formed by the dorsal and ventral margins about 40°.

This rare species is only known from a single specimen preserved in chert, with both extremities wanting. It may be readily distinguished from *P. missouriensis*, of the Chester limestone, and from any other species known in our carboniferous rocks, by its shorter form and greater proportional width.

Position and locality: St. Louis limestone, Monroe county, Illinois.

Collector, H. F. Henckler.

No. 2490 of the Illinois State Museum.

GENUS CONOCARDIUM. Bronn.

CONOCARDIUM PARRISHI. (sp. nov.)

Pl. XX, Fig. 7.

Shell obliquely triangular, hinge line straight, beaks depressed umbonal ridge elevated into a strong rounded fold with faint traces of fine striæ towards the lower extremity. Anterior side evenly and rapidly sloping from the umbonal fold to the extremity, and traversed by radiating costæ only four or five of which extend to the hinge line, but increasing by division and implantation so that ten or more may be counted on the margin of the shell, the one nearest the umbonal ridge being somewhat stronger than the others.

Posterior side flattened towards the extremity, and marked by eight or more flattened striæ nearly all of which extend to the hinge line.

Length about $^{5}/_{16}$ inch.

Position and locality: Oolitic limestone of the upper Coal Measures near Kansas City, Mo.

Collector, W. J. Parrish, of Leavenworth, Kansas, to whom we have dedicated the species.

No. 2605 of the Illinois State Museum.

GENUS AVICULOPECTEN. McCoy.

AVICULOPECTEN ORESTES. Worthen.

Pl. XXII, Fig. 6.

Aviculopecten orestes Worthen, March, 1884, Bulletin No. 2 of the Illinois State Museum of Natural History, page 18.

Shell below the medium size, equilateral, broadly ovate when divested of the ears; hinge line about equal to the greatest breadth of the shell; ears of moderate size and smooth or showing only faint lines of growth; lateral sides diverging for a short distance below the ears, and then broadly rounded into the basal border.

Surface ornamented with about 18 to 20 even, stout, rounded ribs or costæ, that are about twice as wide as the intervening spaces.

Length from beak to base $^{15}/_{16}$ inch; breadth 1 inch; length of hinge line about ⅞ inch. This shell may be readily distinguished from others occurring in the same horizon by its broad rounded costæ.

Named in honor of my friend Prof. Orestes St. John, of Topeka, Kansas.

Position and locality: Keokuk limestone, Warsaw, Ill.

Collector, A. H. Worthen.

No. 2504 of the Illinois State Museum.

AVICULOPECTEN NIOTENSIS. Worthen.

Pl. XXII, Fig. 10.

Aviculopecten niotense Worthen, March, 1884, Bulletin No. 2, of the Illinois State Museum of Natural History. page 19.

Shell large, orbicular, nearly or quite equilateral, length and breadth about equal, hinge line shorter than the greatest width of the shell. Left valve moderately convex, basal margin broadly and evenly rounded, anterior ear short, triangular, and separated from the lateral margin by a well-defined sinus. Posterior ear more than twice as long as the anterior, and pointed at the extremity. Surface of the valve ornamented with numerous fine radiating costæ, of which about fourteen may be counted near the basal margin in the space of half an inch. These costæ appear to become obsolete on the ears and on the lateral borders of the shell.

Length 2¾ inches; breadth about the same; length of hinge line about 2 inches.

This shell may be readily distinguished from the *A. varsoviensis*, described and figured in Vol. VII of these reports, by the much finer radiating costæ with which it is ornamented.

Position and locality: Keokuk limestone, Niota, Hancock county, Illinois.

Collector, A. H. Worthen.

No. 2505 of the Illinois State Museum.

AVICULOPECTEN MONROENSIS. Worthen.

Pl. XXII, Fig. 8-8a.

Aviculopecten monroensis Worthen, March, 1884, Bulletin No. 2 of the Illinois State Museum of Natural History, page 21.

Shell below the medium size, left valve moderately convex, sub-ovate or nearly circular below the ears, the lateral borders gradually rounding into the broadly rounded basal margin. Ears nearly equal in size and ornamented with five or six radiating costæ similar to, and continuous with those on the body of the shell, and also with delicate concentric lines that are plainly visible under an ordinary lens. Surface of the valve ornamented with 60 to 70 irregular sized rounded costæ that are usually a little wider than the intervening spaces, and fine transverse striæ similar to those on the ears, which are only visible under a lens. A right valve belonging apparently to this species is nearly flat, radiating costæ very fine, anterior ear longer than the other and defined by a deep narrow sulcus, and both ornamented with costæ and concentric striæ that are a litttle less conspicuous than those on the opposite valve.

Length of left valve $^{11}/_{16}$ inch; breadth about the same; length of hinge line $^{9}/_{16}$ inch.

Position and locality: Oolitic beds of the St. Louis group, Monroe county, Ill.

Collector, A. H. Worthen.

No. 2509 of the Illinois State Museum.

AVICULOPECTEN TALBOTI. Worthen.

Pl. XXII, Fig, 11-11a.

Aviculopecten talboti Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 21.

Associated with the *A. monroensis*, there is a smaller form that seems to be clearly distinct, and may be characterized as follows:

Shell small, broadly ovate in outline, left valve moderately convex, ears short and not well defined from the lateral borders. Surface apparently smooth, but under a good lens minute radiating and concentric lines may be seen, which are most conspicuous on the ears and lateral borders of the shell.

Length of the largest individual seen ½ inch; breadth about the same; length of hinge line about ¼ of an inch. This form differs from the *A. monroensis* in its smaller size and nearly smooth surface. Named in honor of my friend Henry Talbot, Esq., of Waterloo.

Position and locality: Same as the last.

Collector, A. H. Worthen.

No. 2510 of the Illinois State Museum.

AVICULOPECTEN ELSAHENSIS. Worthen.

Pl. XXII, Fig. 3.

Aviculopecten elsahensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 19.

Shell of medium size, left valve moderately convex, and exclusive of the ears presenting a slightly oblique sub-trigonal outline; hinge line equaling about two-thirds the greatest width of the valve; basal outline forming a somewhat oblique semicircular curve; posterior margin straight from the base of the ear to the basal curve where the valve attains its greatest width. Anterior margin regularly rounded; anterior ear small and obtusely angular; posterior ear large, triangular, and sharply pointed at the extremity. Surface of the ears apparently without ornamentation. Surface of the shell ornamented with numerous radiating costæ that increase by implantation, and are somewhat variable in size, being usually about equal to the intervening spaces.

Length $1^{10}/_{16}$ inches; breadth $1^{11}/_{16}$ inches; length of hinge line 1⅛ inches.

Position and locality: Kinderhook group? half a mile above Elsah, Jersey county, Ill.

Collector, A. H. Worthen.

No. 2506 of the Illinois State Museum.

AVICULOPECTEN CHESTERENSIS. Worthen.

Pl. XXI, Fig. 5-5a.

Aviculopecten chesterensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 20.

Shell above the medium size, nearly equilateral, broadly ovate or semi-circular in outline, a little wider than long; left valve moderately convex, beak depressed and extending slightly beyond the cardinal border. Anterior ear broken away, posterior ear small and ornamented with fine lines of growths. Surface of the valve ornamented with 36 to 40 radiating unequal-sized costæ the alternating ones nearly twice as wide as the others, and all traversed for more than half their length by smaller costæ which become obsolete before reaching the cardinal border. Traces of numerous transverse striæ are also visible where the surface of the shell is well preserved.

Length 2⅜ inches; breadth 2¼ inches.

This shell is closely allied to *A. providensis*, Cox, sp. from the Coal Measures of Kentucky, but differs from that in its smaller and more numerous costæ and transverse striæ.

Position and locality: Lower division of the Chester limestone, Chester, Ill.

Collector, Mrs. J. C. Salter.

No. 2507 of the Illinois State Museum.

AVICULOPECTEN SPINULIFERUS. Meek and Worthen.

Pl. XXII. Fig. 1.

Aviculopecten spinuliferus, Meek and Worthen, 1870, Pro. of the Acad. of Nat. Sc., Phila., and Bulletin No. 2 of the Illinois State Museum of Natural History, page 20.

Shell of medium size, inequilateral, obliquely ovate; left valve moderately convex, and ornamented with about fify angular spinuliferous costæ, each alternate one being about twice as large as the others, the small ones coalescing with the large ones before reaching the cardinal border. Beak moderately elevated, and located about one-third nearer the anterior than the posterior termination of the hinge line. Anterior ear sharply triangular, about half as large as the posterior, and ornamented with three or more spiniferous costæ similar to those on the body of the shell. Posterior ear large and not clearly defined from the lateral border, the spiniferous costæ extending without interruption to the cardinal border. Anterior lateral border neatly rounded from the sinus below the ear to the ventral border.

Length measuring obliquely from the beak to the basal margin $1^{11}/_{16}$ inches; breadth 1¾ inches; length of hinge line 1⅝ inches; posterior ear $^{15}/_{16}$ inch; anterior ear $^{11}/_{16}$ inch. Right valve unknown.

Position and locality: Keokuk shale, Crawfordsville, Indiana.

Collector, Frank H. Bradley.

No. 2508 of the Illinois State Museum.

AVICULOPECTEN MAZONENSIS. (sp. nov.)

Pl. XXII, Fig. 9.

Shell rather below medium size, ovate, slightly inequilateral; left valve moderately convex, the greatest convexity being about $^2/_5$ the distance from the hinge line to the cardinal border.

Hinge line straight, beak depressed, extending slightly beyond the hinge line, and situated a little forward of the middle. Ears nearly equal in size, triangular, and marked by about eight radiating costæ, much smaller than those on the body of the shell. Anterior lateral border regularly rounded from the base of the anterior ear to the cardinal border.

Cardinal border regularly rounded; posterior lateral border nearly straight from the base of the posterior ear to the point where it joins the rounded cardinal border.

Surface of the left valve ornamented with about thirty rounded costæ on the cardinal border, which on the middle of the shell are about as wide as the intervening spaces, but unequal in size. A portion of the costæ becomes obsolete before reaching the hinge line.

Length of a large individual $1^6/_{16}$ inches; breadth about the same; length of hinge line 1 inch.

Position and locality: Coal Measures, Mazon creek, Grundy county, Ill.

No. 2952 of the Illinois State Museum.

AVICULOPECTEN HARDINENSIS. (sp. nov.)

Pl. XXII, Figs. 5-5a.

Shell of medium size, obliquely ovate in form, the length exceeding by about one-tenth the lateral diameter. Basal and lateral margins regularly rounded.

Left valve moderately convex, beak obtuse, hinge line straight, and equal in length to about four-fifths of the greatest lateral diameter. Anterior ear rather narrow, triangular, and sharply defined from the lateral border. Posterior ear broken away.

Test thin and ornamented with longitudinal rays of which about four to five may be counted on the basal border in the space of one-fourth of an inch. The longitudinal rays are crossed by rounded striæ about half the diameter of the rays, giving a strong reticulated character to the surface where the test is well preserved.

Length 2⅜ in., greatest breadth 2¼ inch., length of hinge line about 1⅞ inches.

Position and locality: St. Louis limestone, Hardin county, Illinois.

Collector, A. H. Worthen.

No. 2951 of the Illinois State Museum.

AVICULOPECTEN MAC-WHORTERI. (sp. nov.)

Pl. XXII, Fig. 4.

Shell of medium size, inequilateral; obliquely sub-circular in outline, a little broader than long; hinge line about equal to the greatest breadth of the shell.

Left valve moderately convex, in the umbonal region, and flattened towards the lateral and basal borders. Anterior ear narrow, and clearly defined: posterior ear broader, and not clearly defined from the postero-lateral border, and both ornamented with rounded striæ, similar to those on the body of the shell.

Surface of the valve ornamented with about sixty to sixty-four rounded striæ, each alternate one smaller than the others, and becoming obsolete about half way from the basal margin to the hinge line.

Length 1½ inches, greatest breadth $1^{11}/_{16}$ inches.

Position and locality: Kinderhook group, Kinderhook, Pike county, Ill.

Dedicated to Tyler McWhorter, Esq., of Aledo, Mercer county, Ill., in consideration of his meritorious services as an industrious collector of western fossils.

Collector, A. H. Worthen.

No. 2583 of the Illinois State Museum.

AVICULOPECTEN COLLETTI. Worthen.

Pl. XXII, Figs. 13 and 8b.

Aviculopecten colletti, Worthen. March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 22.

Shell below the medium size, inequilateral, ovate. Left valve slightly convex, ears well defined and unequal in size. Anterior ear small, triangular, posterior ear rather larger than the anterior, ornamented with four or five longitudinal costæ and fine transverse lines of growth, with a well defined notch at its junction with the lateral border. Lateral borders straight nearly to the middle of the valve and thence rounding into the ventral border.

Surface of the valve ornamented with 35 to 40 slightly convex radiating costæ which increase in size towards the free borders of the shell.

Right valve nearly flat, ears rather more prominent than on the opposite valve, and radiating costæ less distinct. Length from the beak to the ventral margin ⅝ inch; greatest breadth $^{11}/_{16}$ inch; length of hinge line, ¾ inch.

Named in honor of Prof. John Collett, the able State Geologist of Indiana.

Position and locality: From the shaly beds of the Keokuk group, Crawfordsville, Indiana.

Collector, Frank H. Bradley.

No. 2512 of the Illinois State Museum.

AVICULOPECTEN EDWARDSI. Worthen.

Pl. XXII, Fig. 2.

Aviculopecten edwardsi, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 22.

Shell of medium size, obliquely ovate, right valve very convex, breadth a little more than the length; anterior ear rather large, triangular, posterior ear not preserved; posterior border oblique, and extending in a nearly straight line from the beak to the basal margin; anterior border moderately rounded from the ear to the basal margin.

Surface of the valve ornamented with ten or twelve rather sharp prominent costæ, with two or three indistinct ones in the intervening spaces on the lower portion of the shell.

Length from beak to base 1 $^3/_{16}$ inches; greatest breadth $1^5/_{16}$ inches; length of anterior ear $^6/_{16}$ inch.

Position and locality: From the upper division of the Keokuk limestone, Warsaw, Ill.

Collector, A. H. Worthen.

No. 2511 of the Illinois State Museum.

AVICULOPECTEN MENARDI. Worthen,

Pl. XXII. Fig. 12.

Lima? menardi, Worthen, March, 1881. Bulletin No. 2, of the Illinois State Museum of Natural History, page 22.

Shell small, thin, obliquely ovate, very inequilateral; ears small, nearly equal in size, triangular; hinge line straight, and about half as long as the greatest width of the shell. Right valve nearly flat; anterior side projecting forward, with a nearly straight margin to the regular curve of the basal margin; posterior side shorter than the anterior, and rounding up from the basal margin nearly to the ear, where it makes a slight backward curve, forming a slight sinus just below the ear.

Surface marked by numerous transverse striæ, that extend from the hinge line quite around the borders of the shell, covering apparently its entire surface. Left valve unknown.

Length from the hinge line to the basal margin, ½ inch; greatest breadth about the same; length of the hinge line ¼ inch.

The only specimen of this pretty shell in the State collection, was obtained from the bituminous shale forming the roof of the Greenview coal in Menard county.

Collector, A. H. Worthen.

No. 2513 of the Illinois State Museum.

GENUS LIMA, Bruguière.

LIMA CHESTERENSIS. (sp. nov.)

Pl. XXII, Fig. 7.

A single valve of a shell belonging apparently to the genus *Lima* was obtained by the writer from a thin layer of ferruginous limestone intercalated in the shales which separate the main limestones at Chester. The specimen represents the right valve with the posterior ear broken away.

This genus has not hitherto been recognized so far as known to the writer in strata below the Coal Measures in this country, but in Europe it has been found in Lower Carboniferous strata, and two species have been described and figured by Prof. L. G. de Koninck from the Carboniferous limestones of Belgium.

Description: Shell of medium size, ovate, umbones depressed, valves moderately convex, the greatest convexity being somewhat nearer the hinge line than the basal margin. Hinge line straight, and about two-thirds as long as the antero-posterior diameter of the valves. Posterior side shorter than the anterior and gradually rounded from the hinge line to the basal margin. Surface ornamented with 28 to 30 rounded striæ, each alternate one being smaller than the others, and extending only about half way to the hinge line.

Height $^{13}/_{16}$ inch; breadth ⅝ inch; length of hinge line $^{7}/_{16}$ inch.

Position and locality: Chester shale, Chester, Ill.

Collector, A. H. Worthen.

No. 2593 of the Illinois State Museum.

GENUS EDMONDIA, DeKoninck.

EDMONDIA VARSOVIENSIS. Worthen.

Pl. XX, Figs. 11-11a.

Edmondia varsovienses, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 18.

Shell above the medium size, compressed and evenly rounded at the extremities; length about one-third greater than the height; basal margin broadly semi-ovate in outline, dorsal margin sloping abruptly from the beaks in front, and nearly straight behind for about two-thirds the entire length of the shell, and thence rounding into the posterior margin; beaks depressed and located near the anterior extremity.

The surface of the cast shows traces of delicate closely arranged concentric striæ, and a few more distinct lines of growth.

Length of the typical specimen 2⅛ inches; height 1⅜ inches. This shell is only known from limestone casts.

Position and locality: From the upper part of the Keokuk limestone, Warsaw, Ill.

Collector, A. H. Worthen.

No. 2502 of the Illinois State Museum.

EDMONDIA ILLINOIENSIS. Worthen.

Pl. XVIII, Figs. 7-7a.

Edmondia illinoiensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 18.

Shell of medium size, transversely sub-oval, convex, broadly rounded at the extremities; dorsal margin straight behind the beak for about two-thirds its length, and thence rounding into the posterior border; basal margin slightly sub-ovate; beak depressed and located about one-third the entire length of the shell from the anterior extremity. Surface of the cast marked by distinct parallel lines of growth.

Length $1\frac{3}{8}$ inches; height $1^1/_{16}$ inches; convexity of the valves about $^5/_{16}$ inch.

This is a smaller and more convex shell than the preceding species, and shows none of the fine concentric striæ that appear on the *E. varsoviensis*.

Position and locality: Same as the preceding species.

Collector, A. H. Worthen.

No. 2503 of the Illinois State Museum.

CLINOPISTHA RADIATA. Hall, sp.

Pl. XIX, Fig. 3, and Pl. XXI, Fig. 2.

Shell elongate oval, height rather less than two-thirds the en tire length; valves moderately convex; posterior extremity truncated, anterior rounded; hinge line straight and equaling about one-half the entire length of the shell.

Beaks depressed and incurved posteriorly. Ventral margin slightly sinuate near the posterior extremity, and sub-parallel with the dorsal.

Surface ornamented with obscure lines of growth and numerous radiating striæ that cross the shell diagonally from the beaks to the anterior and ventral margins.

Length $1^9/_{16}$ inches; height $^{15}/_{16}$ inch; thickness $^{11}/_{16}$ inch.

Position and locality: Coal measures, Mercer county, Ill.

Collector, Tyler McWhorter, Esq.

No. 2586 of the Illinois State Museum.

Genus MACRODON, Lycett.

Macrodon sangamonensis. (sp. nov.)

Pl. XXI, Figs. 3-3a.

Shell large, transversely elongated, hinge line equal to about $^4/_5$ of the entire length of the shell.

Posterior margin compressed and obliquely truncated, so as to meet the hinge line at a rather acute angle; posterior extremity quite narrow, and rounding gently downward to the basal margin.

Anterior margin regularly rounded from the anterior extremity to the basal margin, which is slightly sinuous about the middle.

Beak depressed, strongly incurved, and placed about one-fifth the length of the hinge line from the anterior extremity.

A gradually widening depression extends from the beaks to the posterior extremity on the dorsal margin, and on this flattened portion six or seven strong striæ may be seen, which extend from the beak to the posterior extremity. Strong lines of growth extend around the basal margin, and minute transverse striæ are visible under a lens, especially on the anterior portion of the shell.

Length 2¼ inches; length of hinge 1¾ inches; height $^{15}/_{16}$ inch; convexity of valves $^7/_{16}$ inch.

Position and locality: Coal Measures, Rolls Ford, Sangamon county, Ill.

Collector, A. H. Worthen.

No. 2585 of the Illinois State Museum.

Genus PLEUROPHORUS, King.

Pleurophgrus chesterensis. Worthen.

Pl. XX, Fig. 6.

Pleurophorus chesterensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 16.

Shell of medium size, nearly cylindrical when the valves are closed, almost three times as long as high, most strongly convex on the anterior half of the shell; cardinal margin straight and about equaling three-fourths the entire length of the valves; basal margin slightly sinuous near the middle; anterior extremity broadly rounded and wider than the posterior; beaks depressed and located very near the anterior extremity. An ill-defined radiating ridge extends from behind the beaks obliquely to the posterior margin, between which and the cardinal margin some indistinct traces of longitudinal costæ may be seen.

The specimen is a cast in limestone of both valves slightly displaced. Minute surface markings unknown.

Length $1\frac{9}{16}$ inches, height from beak to base $\frac{5}{8}$ inch.

Position and locality: Chester limestone, Chester, Ill.

Collector, A. H. Worthen.

No. 2501 of the Illinois State Museum.

PLEUROPHORUS MINIMUS. Worthen.

Pl. XX, Figs. 4-4a.

Pleurophorus minimus, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 17.

Shell small, about twice as long as high, moderately convex. Outline elongate ovate. Anterior margin slightly produced forming an obtuse point, posterior margin obliquely truncated; dorsal and ventral margins nearly straight and sub-parallel, the latter rounding up to the obtuse anterior extremity. Beaks depressed, and placed about one-fourth the length of the valve behind the anterior extremity.

Posterior umbonal slopes sub-angular from the beaks obliquely backward and downward to the posterior extremity, with a decided depression between their slopes and the cardinal margin. Surface marked by linear lines of growth, crossed by radiating costæ, which are most strongly defined on the depression of the cardinal area, and on the posterior portion of the shell.

Length $\frac{5}{16}$ inch; height $\frac{1}{8}$ inch; convexity of the valves about $\frac{1}{16}$ inch.

Position and locality: Oolitic beds of the St. Louis limestone, Monroe county, Illinois.

Collector, A. H. Worthen.

No. 2524 of the Illinois State Museum.

PLEUROPHORUS MONROENSIS. Worthen.

Pl. XVIII, Fig. 3-3a.

Pleurophorus monroensis, Worthen, Marsh, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 17.

Shell elongate-oblong, moderately convex; umbonal ridges forming the most convex part of the valves; length about twice as much as the height; a well-defined ridge commencing at the beak extends diagonally to the posterior extremity; anterior ventral region depressed; cardinal margin straight, and rather more than half the entire length of the shell; basal margin nearly straight in the middle, but rounding up in front to the anterior extremity; beaks depressed to the hinge line, and placed about one-fourth the length of the shell behind the anterior extremity, surface smooth.

Length ½ inch; height ¼ inch; convexity about ⅛ inch.

Position and locality: Oolitic beds of the St. Louis group, Monroe county, Ill.

Collector, A. H. Worthen.

No. 2523 of the Illinois State Museum.

GENUS MODIOLA, Lamarck.

MODIOLA ILLINOIENSIS. Worthen.

Pl. XX, Fig. 2-2a.

Modiola illinoiensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum oi Natural History, page 16.

Shell below medium size, length from the anterior to the posterior extremities a little more than twice the width of the valves, narrowing rather rapidly behind the posterior extremity of the hinge line; valves strongly convex in the umbonal region, and obliquely across the valve to the ventral margin, compressed behind; beaks depressed, hinge line equal to three-fifths the entire length. A shallow depression extends from the beak obliquely to the ventral margin in front of the umbonal ridge posterior margin narrowly rounded, anterior extremity obtusely pointed, ventral margin slightly sinuate in the middle, hinge line straight, surface nearly smooth but showing a few obscure lines of growth.

Length of an average size specimen $^{15}/_{16}$ inch; breadth at the posterior extremity of the hinge line $^{7}/_{16}$ inch; convexity of the valve about $^{3}/_{16}$ inch.

Position and locality: From the oolitic beds of the St. Louis group, Monroe county, Ill.

Collector, A. H. Worthen.

No. 2518 of the Illinois State Museum.

GENUS CARDIOMORPHA, DeKoninck.

CARDIOMORPHA? PELLENSIS. Worthen.

Pl. XIX, Figs. 9–9a, 9b.

Cardiomorpha pellaensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 16.

Shell longitudinally sub-ovate, length less than once and a half the height; dorsal and ventral borders sub-parallel, dorsal margin nearly straight, ventral margin moderately curved; valves convex, the greatest convexity being about one-third the distance from the beaks to the ventral margin; beaks depressed and placed close to the anterior extremity which is nearly straight above, and curving below into the ventral margin; posterior extremity cuneate.

The specimen is a cast in a calcareous shale, and shows no surface ornamentation.

Length $^{11}/_{16}$ inch; height $^{7}/_{16}$ inch; thickness $^{5}/_{16}$ inch.

Position and locality: Shaly limestone of the St. Louis group, Pella, Iowa.

Collector, A. H. Worthen.

No. 2516 of the Illinois State Museum.

GENUS BAKEVELLIA, King.

BAKEVELLIA ILLINOIENSIS. Worthen.

Pl. XVIII, Fig. 4–4a.

Bakevellia illinoiensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 14.

Shell about medium size, elongate sub-rhomboidal, left valve moderately convex from a ridge which extends from the beak about two-thirds the distance to the cardinal border where it becomes obsolete.

This ridge slopes abruptly to the dorsal margin, and more gradually to the anterior portion of the shell. Posterior wing equal to about two-fifths of the entire length of the shell. Umbonal region squarely truncated at the apex, upper portion of the anterior margin nearly straight to the point where it joins the ventral portion of the valve, or about one-fourth its entire length. Surface ornamented with numerous concentric lines of growth, which are closely arranged on the umbo, but become more widely spaced on the lower margins of the shell. Right valve unknown.

Length 1⅛ inches; greatest breadth about ½ inch; convexity of left valve ¼ inch.

Position and locality: Upper Coal Measures, LaSalle, Ill.

Collector, A. H. Worthen.

No. 2525 of the Illinois State Museum.

GENUS MYALINA, DeKoninck.

MYALINA MONROENSIS. Worthen.

Pl. XX, Figs. 10-10a.

Myalina monroensis, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 15.

Shell small, nearly equivalve, moderately convex on the umbonal slopes from the beaks two-thirds the distance to the posterior extremity, becoming gradually depressed below. Posterior and postero-lateral regions cuneate; cardinal margin nearly straight, and about half as long as the valves, gradually rounding below to the basal extremity. Beaks small, slightly oblique, and not projecting beyond the cardinal margin. Angle of the anterior and posterior margin about 50°. Surface smooth, or with very obscure traces of lines of growth. Length of a medium size specimen $^{12}/_{16}$ inch; greatest width of the valve $^{7}/_{16}$ inch, convexity of valve about ⅛ inch.

Position and locality: Oolitic beds of the St. Louis group, Monroe county, Ill.

Collector, A. H. Worthen.

No. 2522 of the Illinois State Museum.

GENUS NUCULA, Lamarck.

NUCULA ILLINOIENSIS. Worthen.

Pl. XIX, Figs. 4-4a.

Nucula illinoiensis, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 15.

Shell small, transversely ovate, depressed convex, the greatest convexity about the middle of the valves; slightly excavated in front of the beaks; anterior end regularly rounded to the ventral margin, dorsal outline declining moderately from the beaks to the posterior extremity; ventral margin slightly curved; beaks depressed and situated about one-third the distance from the anterior to the posterior extremity.

Length $^6/_{16}$ inch; height $^4/_{16}$ inch. Surface nearly smooth, but in some of the specimens, faint lines of growth may be seen with a good lens around the borders of the shell.

Position and locality: Oolitic bed of the St. Louis limestone, Monroe county, Ill.

Collector, A. H. Worthen.

No. 2519 of the Illinois State Museum.

GENUS AVICULOPINNA, Meek.

AVICULOPINNA ILLINOIENSIS. Worthen.

Pl. XX, Figs. 5-5a.

Aviculopinna illinoiensis, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 13.

Shell rather larger than the typical species, valves moderately and about equally convex, cardinal and ventral margins curved, and converging gradually from the base to the apex. Surface ornamented with numerous thread-like lines or lamellæ that curve gracefully round to the dorsal margin, and are separated by rather broad spaces on the dorsal portion of the valve. The apex is broken away so that its form cannot be determined.

Length $1^9/_{10}$ inches; greatest width ⅞ inch; greatest thickness ½ inch. This species differs from the *A. americana*, in the curvature of its margins and the greater convexity of the valves.

Position and locality: Coal Measures, Peoria county, Ill.
Collector, Mr. Gifford.
No. 2529 of the Illinois State Museum.

GENUS SANGUINOLITES, McCoy.

SANGUINOLITES? MULTISTRIATUS. Worthen.

Pl. XIX, Fig. 2.

Sanguinolites ? multistriatus, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 14.

The specimen from which the following description is drawn, is a cast from the shaly sandstone of the Keokuk group, and may be characterized as follows:

Shell below the medium size, oblong, valves moderately convex; beaks depressed, and situated about one-third the entire length of the shell behind the anterior extremity.

Dorsal line straight, basal border slightly rounded, extremities obtusely pointed and apparently gaping, surface marked by numerous fine concentric striæ that are most conspicuous on the posterior portion of the valves. The specimen is somewhat distorted by pressure, so that its exact proportions cannot be determined.

Length 1 inch; height ⅜ inch.

Position and locality- Keokuk shales near Crawfordsville, Indiana.

Collector, Frank H. Bradley.

No. 2528 of the Illinois State Museum.

SANGUINOLITES? BURLINGTONENSIS. Worthen.

Pl. XX, Figs. 8-8a.

Sanguinolites? burlingtonensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 14.

Shell of medium size, longitudinally elongate-ovate, more than twice as long as high, moderately and evenly convex anteriorly, and regularly depressed towards the posterior extremity. Cardinal margin slightly depressed in the middle and elevated behind, giving a greater breadth to the posterior than the anterior region.

Beaks not prominent, and situated close to the anterior extremity. The specimen is a cast, and shows no surface markings.

Length $1^{7}/_{16}$ inches; greatest height $^{11}/_{16}$ inch.

Position and locality: Burlington limestone, Calhoun county, Illinois.

Collector, A. H. Worthen.

No. 2541 of the Illinois State Museum.

SANGUINOLITES RANDOLPHENSIS. Worthen.

Pl. XX, Figs. 1-1a.

Cypricardia? randolphensis, Worthen, 1883, Geol. Surv. of Illinois, Vol. VII, page 326.

Shell oblong, height from beak to the ventral margin about equal to half the length, valves moderately convex on the anterior portion of the shell, and depressed towards the posterior extremity, where the valves were apparently closely joined. Beaks rather large, depressed, and incurved beyond the dorsal margin, and situated about two-fifths the distance from the anterior to the posterior extremities. A broad and slightly flattened depression appears on some of the specimens, extending from the beak to the ventral margin of the shell.

Dorsal margin nearly straight, ventral margin parallel with the dorsal for about two-thirds of its length, curving abruptly upward on the anterior and more gently on the posterior extremity. Lunule ovate; surface markings unknown.

Length of an average size specimen 2⅝ inches; height 1⅜ inches; thickness $^{15}/_{16}$ inch.

All the specimens obtained are casts in limestone.

Position and locality. Chester limestone, upper bed at Chester, Illinois.

Collector, A. H. Worthen.

No. 2491 of the Illinois State Museum.

GENUS SOLENOMYA. Lamarck.

SOLENOMYA VARSOVIENSIS. Worthen.

Pl. XIX, Fig. 8.

Solenomya Varsoviensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 12.

Shell rather large, elongate-oval or sub-elliptical in outline, moderately convex, and apparently closed at the extremities. The greatest convexity of the valves is in the umbonal region, and thence obliquely to the ventral margin, and, in front of this elevated region, a slight depression may be seen which extends nearly to the anterior extremity. Beaks depressed and recurved towards the posterior margin, and located a little less than one-third the entire length of the valve behind the anterior extremity.

Dorsal and ventral margins nearly straight and sub-parallel, anterior extremity rather narrow, and the posterior broadly rounded.

Surface of the cast marked by a few obscure wrinkles near the umbo, and lines of growth towards the ventral margin.

Length about 3 inches; height from the beak to the ventral margin 1¼ inches; convexity of the valves about $^7/_{16}$ inch.

Position and locality; Keokuk limestone, Warsaw, Illinois.

Collector, A. H. Worthen.

No. 2539 of the Illinois State Museum.

SOLENOMYA MONROENSIS. Worthen.

Pl. XVIII, Fig. 5-5a.

Solenomya Monroensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 13.

Shell below the medium size, oblong, the length being a little more than twice the height from the beak to the ventral margin; valves moderately convex, the greatest convexity being obliquely along the umbonal slopes from the beaks to the ventral margin; cardinal margin straight and about three-fifths the entire length of the valve; basal margin slightly sinuous, from a shallow depression that extends obliquely from the beaks to the opposite margins, extremities rounded; beaks depressed, oblique, and located about one-sixth the entire length of the valves behind the anterior extremity.

Surface smooth or showing only a few obscure lines of growth.

Length of the largest specimen obtained $^{13}/_{16}$ inch; height from beak to base $^{6}/_{16}$ inch.

Position and locality: Obtained from the oolitic beds of the St. Louis limestone on Fountain Creek, Monroe county, Ill.

Collector, A. H. Worthen.

No. 2515 of the Illinois State Museum.

SOLENOMYA? IOWENSIS. Worthen.

Pl. XIX, Fig. 5-5a.

Solenomya? Iowensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 13.

Shell small, narrow, oblong, valves apparently closed at each extremity.

Dorsal and ventral margins nearly parallel, beaks depressed and situated close to the anterior extremity. Surface markings unknown.

Length of the largest specimen $^{7}/_{10}$ inch; height ¼ inch; thickness ⅛ inch. This little shell is only known from a few casts obtained from the shaly layers of the St. Louis limestone near Pella, Iowa, where it was associated with *Allorisma marionensis*, *Rhynchonella ottumwa*, *Spirifer littoni* and *Zaphrentis* sp?

Collector, A. H. Worthen.

No. 2517 of the Illinois State Museum.

GENUS ALLORISMA, King.

ALLORISMA ILLINOIENSIS. Worthen.

Pl. XVIII, Fig. 1-1a.

Allorisma illinoiensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 11.

Shell large, elongate-ovate, length a little more than twice the height; valves moderately convex, extremities broadly rounded; dorsal margin straight and nearly parallel with the base; anterior extremity short and rather more narrowly rounded than the posterior, and descending obliquely from the beaks. Beaks compressed, extending beyond the cardinal border, and located about one-fourth the entire length of the shell behind the anterior extremity. Surface of the cast ornamented with rather strong parallel lines of growth.

Length $3^9/_{16}$ inches; height from the beak to the basal margin $1\frac{1}{2}$ inches; convexity of the valves about $^7/_{16}$ inch.

This species resembles *A. subcuneata* in size and form, but lacks the concentric undulations of that species.

Position and locality: Keokuk limestone, Warsaw, Ill.

Collector, A. H. Worthen.

No. 2540 of the Illinois State Museum.

ALLOR SMA ELONGATA. Worthen.

Pl. XIX, Fig. 10.

Allorisma elongata, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 12.

Shell large, very elongate, dorsal and ventral margins nearly straight and parallel; length three times as great as the height; greatest convexity in the umbonal region; cuneate and perhaps a little gaping behind, with a rather narrowly rounded outline. Beaks recurved, approximate, and located near the anterior extremity. Anterior margin evenly rounded. The surface of the cast shows numerous concentric undulations that are much smaller and more numerous than in *A. subcuneata*, its nearest representative form.

Length $3^{15}/_{16}$ inches; height $1^5/_{16}$ inches; breadth near the umbo $1\frac{1}{8}$ inches.

Position and locality: Keokuk limestone, Warsaw, Ill.

Collector, A. H. Worthen.

No. 2542 of the Illinois State Museum.

PTEROPODA.

GENUS CONULARIA. Miller.

CONULARIA CHESTERENSIS. Worthen.

Pl. XI, Fig. 9-9a.

Conularia chesterensis Worthen, 1883. Geol. Surv. of Illinois, Vol. VII, page 325.

Shell attaining a medium size, long and rather slender, gradually tapering, nearly equally four-sided, the four angles being distinctly and rather deeply furrowed, while a slight furrow marks the median line on each side. The sides are crossed by numerous raised costæ, which arch slightly forward from the angles to the median line, making an angle with that line of about 14°. These costæ do not cross the angular furrows, but are alternately arranged so that those on one side terminate at the intervening space between those on the opposite side.

These spaces are about twice as wide as the costæ, and are widest at the median line.

The aperture is not well preserved in any of our specimens, but the shell was evidently notched at the angles, and was probably contracted at the aperture.

Length of a rather large individual, 5 inches; breadth between the angles near the aperture, 1 inch; number of costæ in the space of an inch near the aperture, 20; near the apex, 30.

Position and locality: Chester limestone, Chester, Illinois.

Collector A. H. Worthen.

No. 2489 of the Illinois State Museum.

GASTEROPODA.

GENUS PLEUROTOMARIA, Defrance.

PLEUROTOMARIA ILLINOIENSIS. Worthen.

Pl. XXIII, Figs. 6-6a-6b.

Pleurotomaria illinoiensis, Worthen, March. 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, p. 4.

Shell discoidal, spire but slightly elevated; outer angle of the last volution sharp, volutions about five, aperture ovate. Suture line marked by a row of small nodes, of which about ten may be counted on the last volution. A revolving slightly impressed band may be seen with a good lens above the outer angle of the last volution, which probably joins the sinus in the lip; umbilicus shallow.

This shell is most nearly related to the flat variety of *P. sphærulata*, described by Prof. Cox, under the name of *P. depressa*, but differs from that in its more flattened volutions, the impressed band on the lower volution, and its smaller and less conspicuous nodes.

Breadth of an average size specimen $^9/_{16}$ inch; height $^3/_{16}$ inch.

Position and locality: From a black limestone over one of the lower coal seams in Mercer county, Ill.

Collector, A. H. Worthen.

No. 2530 of the Illinois State Museum.

PLEUROTOMARIA GIFFORDI. Worthen.

Pl. XXIII, Figs. 8-8a.

Pleurotomaria giffordi, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 5.

Shell small, conical, volutions about seven, spire sharply elevated, the last volution forming less than half the entire length, and ornamented below the spiral band with nine or ten revolving lines, that decrease in number on the succeeding volutions.

Spiral band concave and located a little above the middle of the lower volution, and defined by two strong revolving lines, the upper one of which is the strongest. There are also two or three revolving lines within the spiral band, and three or four on the upper angle of the volution, the last one of which is much stronger than the others.

Length $^6/_{16}$ inch, diameter of the outer volution about $^4/_{16}$ inch; spiral angle about 43°.

This shell is nearly related to *P. subconstricta*, Meek and Worthen, described and figured in Vol. II of these reports, page 351, Pl. 28, fig. 6, but differs from that in its surface ornamentation, and especially in its spiral angle.

Position and locality: Coal Measures, Peoria county, Ill.

Collector, Mr. Gifford.

No. 2535 of the Illinois State Museum.

PLEUROTOMARIA MONTEZUMA. Worthen.

Pl. XXIV, Fig. 2.

Pleurotomaria montezuma, Worthen, 1883. Geol. Surv. of Illinois, Vol. VII, page 324.

This fine shell is only known from an imperfect cast of the last volution.

Shell attaining a large size, broadly conical in outline; whorls three or more, diminishing rapidly in size towards the apex. Last whorl obliquely flattened, showing a lateral surface about two inches in breadth. This is traversed by about eight rather strong revolving striæ, separated by shallow depressions that are about ⅜ of an inch wide near the aperture. The under side of this volution was also traversed by revolving striæ about half as widely separated as those on the side of the volution, but their number cannot be accurately determined from the imperfect state of preservation of the only individual yet obtained. A raised line around the inner side of the volution, indicates the presence of a rather wide and deep umbilicus.

Greatest diameter of the last volution, 4⅝ inches; height of the volution 1⅛ inches.

Position and locality: Burlington limestone, Montezuma, Pike county, Illinois.

Collector, A. H. Worthen.

No. 2487 of the Illinois State Museum.

PLEUROTOMARIA ADAMSI. Worthen.

Pl. XXIII, Figs. 5-5a.

Pleurotomaria adamsi, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 5.

Shell small, trochiform, conical; length a little more than the diameter of the lower volution. Volutions about six, the last one flat and smooth below the spiral band, umbilical region concave; spiral band prominent, deeply groved, and occupying the angle on the periphery of the lower volution, becoming shallower and less prominent on those above. The elevations defining the upper and lower margins of the spiral band are marked by one or two revolving lines visible with an ordinary glass, which continue on the succeeding volutions where the spiral band becomes obsolete.

Length $^5/_{16}$ inch; diameter of the last volution $^4/_{16}$ inch; spiral angle about 60°.

Named in honor of Mr. W. H. Adams of Peoria county, from whom some of the specimens were obtained.

Position and locality: Coal Measures, Peoria county, Ill.

Collector, W. H. Adams.

No. 2536 of the Illinois State Museum.

PLEUROTOMARIA NAUVOOENSIS. Worthen.

Pl. XXV, Fig. 3.

Pleurotomaria nauvooensis, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 5.

This form is represented in the State collection by a single cast in limestone from the upper part of the Keokuk limestone at Navoo.

Shell above the medium size, consisting of about four obliquely flattened volutions, the lower one forming about half the entire length. The periphery of the lower volution shows a flattened space about a quarter of an inch in width that was probably occupied by a spiral band. Form of aperture and surface markings unknown.

Length of the three lower volutions 1¾ inches; greatest breadth 1¼ inches.

Collector, A. H. Worthen.

No. 2493 of the Illinois State Museum.

PEUROTOMARIA IOWENSIS. (sp. nov.)

Pl. XXIV. Fig. 2.

Pleurotomaria Coxana, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 6.

When this species was described in 1884, the fact that the specific name *coxana*, was already occupied for a Coal Measure form was overlooked, and therefore the name *iowensis* is now substituted for the one originally proposed.

Shell large, broadly umbilicated, spire moderately extended, its length being equal to about one-third the full length of the shell; volutions about four, strongly and evenly convex above, and increasing gradually in size, the last one abruptly rounded below into the umbilicus; aperture apparently subovate. The specimen is a cast in limestone, and the surface was probably nearly smooth, as the fragments of the adhering test show no external markings.

Length 2¼ inches; breadth 1¾ inches; diameter of the last volution $1^6/_{16}$ inches.

Position and locality: Keokuk limestone, Keokuk, Iowa.

Collector, Mr. L. A. Cox.

No. 2547 of the Illinois State Museum.

GENUS PORCELLIA, Leveille.

PORCELLIA PEORIENSIS. Worthen.

Pl. XXIII, Fig. 4-4a, 4b.

Porcellia Peoriensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 6.

Shell small, volutions about five, closely embracing and very gradually enlarging, the last one marked by a narrow dorsal band, defined by a sharp elevated ridge on either side. Outer volution ornamented also with a row of about nine small nodes on either side, which are situated about one-third the distance from the inner margin to the dorsal band. Umbilical depression broad and shallow.

The surface of the shell in some of our specimens is thickly pitted with small rounded depressions that are plainly visible under a good lens, but they may, however, be due to some secondary cause.

Greatest diameter of the shell ½ inch; transverse diameter of the outer volution ¼ inch.

Position and locality: This rare and beautiful little shell was found in the lower Coal Measures of Peoria county, Ill.

Collector, Mr. Gifford.

No. 2531 of the Illinois State Museum.

GENUS LOXONEMA, Phillips.

LOXONEMA PEORIENSE. Worthen.

Pl. XXIII, Fig. 10-10a, 10b.

Loxonema Peoriensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 7.

Shell below the medium size, elongate conical, spire very gradually tapering to a minute point. Volutions about sixteen, convex, increasing very gradually in size; the lower ones a little flattened above the middle. Suture moderately deep, surface smooth. Aperture nearly round.

Length ¾ inch; diameter of the lower volution $^3/_{16}$ inch. Spiral angle 16°.

This species is nearly related to *L. cerithiformis* of Meek and Worthen, described and figured in Vol. II of these reports, page 379, Pl. 31, fig. 13, a, b, c, but may be readily distinguished from that, by its more slender form and more numerous volutions.

Position and locality: Coal Measures, Peoria county, Ill.

Collector, Mr. Gifford.

No. 2532 of the Illinois State Museum.

LOXONEMA QUADRI-CARINATUM. Worthen.

Pl. XXIII, Fig. 9-9a.

Loxonema quadri-carinatus, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 7.

Shell long, cylindrical, gradually tapering; volutions eight or more, convex, the last one sloping abruptly to the umbilical region below, and more gradually to the suture above. Volutions ornamented with three strong revolving carinæ on the lower portion of the volutions, and a less defined one on the upper sloping side below the suture. Transverse lines of growth are visible under a lens on the abruptly sloping under side of the last volution. Aperture ovate.

Length of a specimen preserving six volutions $^{13}/_{16}$ inch; diameter of the lower volution $^{6}/_{16}$ inch. Spiral angle 25.°

Position and locality: Coal Measures, Peoria county, Ill.

Collector, Mr. Gifford.

No. 2534 of the Illinois State Museum.

GENUS LEPETOPSIS, Whitfield.

LEPETOPSIS CHESTERENSIS. Worthen.

Pl. XXV, Figs. 1-1a,

Lepetopsis chesterensis, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 25.

Shell of medium size, longitudinally ovate, anterior and posterior portions regularly rounded and about equal in length, a little broader behind than in front, apex pointed, and directed slightly backward, height equal to about one-third the greatest length; A shallow depression or sinus commences immediately behind the apex and increases rapidly in width the posterior margin. Surface ornamented with numerous somewhat irregular sized concentric lines that arch upward in crossing the sinus-like depression behind the apex.

Length $^{9}/_{10}$ of an inch; greatest breadth $^{7}/_{10}$ inch; height about $^{3}/_{10}$ inch.

This species is related to *L. levetti*, of the Warsaw beds, but may be distinguished by its more elongate form, and the sinus-like depression behind the apex.

Position and locality: Lower division of the Chester limestone, Chester, Ill.

Collector, Mrs. J, C. Salter.

No. 2514 of the Illinois State Museum.

GENUS MURCHISONIA, D'Arch. and Vern.

MURCHISONIA KEOKUK. (sp. nov.)

Pl. XXIII, Figs. 2–2a.

Several casts of a long spiral shell have been found in the Keokuk limestone, which seem to belong to the genus *Murchisonia*, but none of them retain any portion of the test, and consequently nothing is known of their external characters.

These casts all have an elongated form that tapers very gradually to the apex. Volutions about six, the upper ones rather more regularly rounded than the last; suture wide and deep. Aperture apparently ovate.

Length of a cast with five volutions, nearly 4 inches; greatest breadth of the last volution 1⅛ inches; transverse diameter of the same ½ inch.

Position and locality: Keokuk limestone, Keokuk, Iowa.

The specimens figured were kindly loaned by Mr. L. A. Cox, of Keokuk.

MURCHISONIA LASALLENSIS. (sp. nov.)

Pl. XXV, Figs. 7–7a.

Shell turriculate, slender, spire pointed at the summit, composed of eleven or more volutions, which are elevated in the middle into a prominent carina, and separated by a profound suture.

On the last volution there is a flattened band below the carina, which is bounded below by a slight elevation. Neither the flattened band nor the elevation below extend to the other volutions.

Length of the shell ¾ inch; breadth of the last volution $^3/_{16}$ inch; spiral angle about 22°.

This little shell is closely related to *M. sub-angulata*, of Verneuil and Keyserling*, but differs in the greater number of its

* Geology of Russia and the Ural Mountains, Vol. II, page 340, Pl. XXII, Fig. 6.

volutions, more strongly prominent carina, and in the flattened band on the lower volution.

Locality and position: Upper Coal Measures, LaSalle, Illinois.

Collector, A. H. Worthen.

No. 2603 of the Illinois State Museum.

GENUS STRAPAROLLUS. Montfort.

STRAPAROLLUS SUB-UMBILICATUS. (sp. nov.)

Pl. XXIV, Figs. 3-3a-3b.

Shell small, conical, whorls five, flattened above, rounded on the periphery and sharply rounded below into the umbilicus.

Umbilicus deep and rather wider than the diameter of the outer volution near the aperture. Surface without ornamentation, except some faint lines of growth.

Diameter of a medium size specimen $^6/_{16}$ inch; height of the same $^5/_{16}$ inch.

This little shell is closely related to the *S. umbilicatus*, Meek and Worthen, of the Coal Measures, but differs from that species in its comparatively narrow umbilicus, and much smaller size. Of more than twenty specimens obtained, none attain a diameter of more than half an inch.

Position and locality: Calcareous shales of the Chester group, near Evansville, Randolph county, Ill.

Collector, A. H. Worthen.

No. 2602 of the Illinois State Museum.

STRAPAROLLUS VARSOVIENSIS. (sp. nov.)

Pl. XXV, Figs. 2-2a.

Shell lenticular, whorls about four, gradually increasing in size; spire moderately elevated above the body whorl. Volutions somewhat flattened above, and regularly rounded on the periphery, and more gently below into the umbilicus.

The umbilicus is filled with the stony matrix, but is apparently somewhat less in width than the diameter of the outer whorl.

The specimen is a cast in limestone, and no external markings are apparent.

Height $^7/_{16}$ inch; greatest breadth $^{13}/_{16}$ inch; breadth of the aperture $^6/_{16}$ inch.

Position and locality: Upper beds of the Keokuk limestone, Warsaw, Ill.

Collector, A. H. Worthen.

No. 2599 of the Illinois State Museum.

Genus MACROCHEILUS, Phillips.

Macrocheilus altonensis. (sp. nov.)

Pl. XXIV, Figs. 1-1a.

Shell of medium size, subfusiform, symmetrically conical above the last volution.

Volutions about six, moderately ventricose, the last one about equal to the length of the spire above. Suture well defined. Aperture elongate ovate; surface markings unkown.

The specimen is a cast in limestone, but clearly shows the characteristics of the genus.

Length 1⅝ inches; length of the last volution 1 inch; breadth of the same ⅝ inch; length of aperture ⅝ inch; greatest breadth of the same ½ inch.

Position and locality: St. Louis limestone, Alton, Illinois.

Collector, A. H. Worthen.

No. 2598 of the Illinois State Museum.

Genus BELLEROPHON, Montfort.

Bellerophon giganteus. Worthen.

Pl. XXV, Figs. 5-5a.

Bellerophon giganteus Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 8.

Shell very large, sub-globose; volutions expanding rapidly, rounded over the dorsum and sides; umbilical region deeply excavated. Aperture reniform or sublunate, mesial band not shown on the cast. Fragments of the shell adhering show that it was comparatively thick.

Greatest breadth of the aperture about 4 inches; height of the same $2\frac{1}{2}$ inches; length from front to back $3^{13}/_{16}$ inches.

This shell is only known from a cast in limestone, but it may be readily distinguished by its size and general form from all known American species.

Position and locality: Lower Coal Measures, Monroe county, Illinois.

Collector, A. H. Worthen.

No. 2543 of the Illinois State Museum.

GENUS NATICOPSIS. McCoy.

NATICOPSIS MADISONENSIS. Worthen.

Pl. XXV, Figs. 4,6.

Naticopsis madisonensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 9.

Shell large, sub-rhomboidal or sub-rectangular in outline; volutions about three, the last one comprising more than two-thirds the entire length of the shell, all rounded, and the last quite gibbous; umbilicus deep, aperture apparently subcircular. The specimen is a cast in limestone, and shows no external markings except some faint lines of growth.

Length $2^{1}/_{16}$ inches; breath of the last volution $1^{5}/_{16}$ inches.

In form and size this shell approaches most nearly to *N. giganteus* of the Coal Measures, but it differs from that in having one less volution, and it also lacks the flattened depression on the outer volution which characterizes that species.

Position and locality: St. Louis limestone, Madison county, Illinois.

Collector, A. H. Worthen.

No. 2546 of the Illinois State Museum.

GENUS POLYPHEMOPSIS. Portlock.

POLYPHEMOPSIS? KEOKUK. Worthen.

Pl. XXIII, Fig. 3.

Polyphemopsis? Keokuk, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 9.

A cast of this shell in limestone from the lower portion of the Keokuk limestone in the vicinity of Keokuk presents the following characters:

Shell about the medium size, consisting of about five moderately convex volutions, the last one constituting more than one-half the entire length. The volutions taper gradually, and present no indications of external ornamentation.

Exact form of aperture unknown. Length of the four volutions preserved, 2⅝ inches; length of last volution, 1½ inches; breadth of the same where it seems to be somewhat flattened by pressure, ¾ inch.

Collector, Mr. L. A. Cox, of Keokuk.

No. 2494 of the Illinois State Museum.

Genus DENTALIUM. Linnæus.

Dentalium illinoiense. Worthen.

Pl. XXIII, Fig. 1.

Dentalium illinoiense, Worthen, 1883. Geol. Surv. of Illinois, Vol. VII, page 325.

Shell above a medium size, long, straight, cylindrical, slightly tapering, scarcely inflated at the aperture. Surface apparently smooth originally, but slightly roughened by weathering in the specimen under examination.

Length 5⅝ inches; width near the aperture, $^7/_{16}$ inch.

This species differs from *D. missouriense* of Swallow, in its larger size, smooth surface and straight form.

Position and locality: Chester limestone, Chester, Ill.

Collector, A. H. Worthen.

No. 2488 of the Illinois State Museum.

Genus ORTHONEMA. Meek and Worthen.

Orthonema carbonarium. Worthen.

Pl. XXIV, Figs. 4–4a.

Orthonema carbonaria, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 7.

Shell very elongate, gradually tapering from the base to the apex, with nine or more flattened volutions that are defined above and below by a narrow suture, and a strong revolving carina. Under side of the last volution obliquely flattened; umbilicus closed. Form of aperture not clearly defined, but apparently subovate. Lines of growth are clearly visible on the flat portions of the volutions. Length of a specimen showing seven volutions, $^{10}/_{16}$ inch; diameter of lower volution ¼ inch. Spiral angle about 20°.

This shell is known only from an imperfect example, and is nearly related to *O. salteri*, of Meek and Worthen, Vol. II, of these reports, page 381, Pl. 31, fig. 14, a, b, c, but differs from that, in its surface ornamentation and its spiral angle.

Position and locality: Coal Measures, Peoria county, Ill.

Collector, Mr. Gifford.

No. 2533 of the Illinois State Museum.

GENUS TRACHYDOMIA. Meek and Worthen.

TRACHYDOMIA NODULOSA. Worthen.

Pl. XXIII, Figs. 11-11a.

Trachydomia nodulosa. Worthen, March' 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 8.

Shell of medium size, obliquely ovate or sub-rhomboidal in outline, volutions four, the last one comparatively large and comprising more than two-thirds the entire length, rounded below and slightly flattened above to the nearly perpendicular lower border of the rather deeply impressed suture. Aperture nearly sub-ovate with a well defined notch at its lower extremity; lip sharp, columella flattened and smooth; surface thickly covered with prominent rounded nodes that are largest on the upper edge of the volution, and increase in number as they decrease in size towards the umbilical region. The nodes become obsolete on the lower extremity of the last volution, leaving a limited space around the lip that is ornamented only with a few rather coarse lines of growth.

Length of an average size specimen $^{10}/_{16}$ inch; breadth $^{7}/_{16}$ inch.

This shell is about midway in form and size between *T. wheeleri* and *T. hollidayi,* but differs from both in the form of its aperture, and from the latter also in its more numerous and differently formed nodes.

Position and locality: Coal Measures, Peoria county, Ill.

Collectors, W. H. Adams and Mr. Gifford.

No. 2538 of the Illinois State Museum.

CLASS CEPHALOPODA.

GENUS NAUTILUS. Breynius.

NAUTILUS MONTGOMERYENSIS. Worthen.

Pl. XXVI, Fig. 2 and XXVII, fig. 1.

Nautilus montgomeryensis, Worthen, March, 1884. Bulletin No. 2, of the Illinois State Museum of Natural History, page 4.

Shell of medium size, sub-globose, volutions two or more, rapidly expanding; outer septum regularly rounded in front and on the sides, wider than long, with a wide and deep sinus in the middle of its dorsal border for the reception of the broad tongue-like projection of the next septum. The succeeding septa are much narrower, and more broadly curved on their dorsal sides, with a long and broad tongue-like projection in the middle that fills the sinus of the preceding septum. Position of the siphuncle unknown. The specimen is a cast in clay iron-stone and shows no surface ornamentation.

Aperture reniform in shape, and $3^3/_{34}$ inches in breadth by 1⅝ inches in height. Length of the shell from front to back 3½ inches.

Position and locality: Upper Coal Measures, Montgomery county, Ill.

Collector unknown.

No. 2544 of the Illinois State Museum.

GENUS ORTHOCERAS. Breynius.

ORTHOCERAS ILLINOIENSE. Worthen.

Pl. XXVI, Figs. 1,1a, 1b.

Orthoceras illinoiense, Worthen, 1883. Geol. Surv. of Illinois, Vol. VII, page 323.

Shell of medium size, gradually enlarging from the apex; section slightly ovate, siphuncle rather large, and placed near the margin of the shell. Septa moderately convex and oblique to the axis, being arched strongly upward on the siphuncular side, and equaling in width about one-fifth the shortest diameter of the shell. Surface markings unknown.

Length of the largest specimen seen, about 6 inches; greatest width at the apex ⅝ inch; diameter of outer chamber 2½ inches.

Position and locality: Chester limestone, Chester, Ill.

Collector, A. H. Worthen.

No. 2484 of the Illinois State Museum.

Orthoceras okawense. Worthen.

Pl. XXVI, Fig. 3.

Orthoceras okawense, Worthen, 1883. Geol. Surv. of Illinois, Vol. VII, page 324.

Shell elongate, slender, very gradually tapering to the apex; septa concave, about four of them in the space of one diameter. Siphuncle sub-central; surface markings unknown.

This shell has a general resemblance to *O. rushense*, McChesney of the Upper Coal Measures, but differs from it in the position of the siphuncle, which in our species is decidedly subcentral.

Position and locality: Chester limestone, near Red Bud, Randolph county, Ill.

Collector, A. H. Worthen.

No. 2485 of the Illinois State Museum.

Orthoceras lasallense. Worthen.

Pl. XXVI, Figs. 4-4a.

Orthoceras lasallense, Worthen, 1883. Geol. Survey of Illinois, Vol. VII, page 324.

Shell small, gradually tapering. Surface ornament with transverse ridges or elevations, situated at regular distances from each other, and with delicate thread-like striæ which cover the transverse ridges as well as the spaces between them.

The ridges and striæ will serve to distinguish this species from any hitherto described from the Coal Measures, its ornamentation resembling a Silurian form, *O. undulatum*, of the Niagara limestone, more closely than any other known American species. The fragment preserved and figured seems to belong to the nonseptate portion of the shell.

Position and locality: Roof of the middle coal seam, LaSalle, Illinois.

Collector, A. H. Worthen.

No. 2486 of the Illinois State Museum.

Genus GONIATITES. DeHaan.

Goniatites monroensis. (sp. nov.)

Pl. XXVI, Fig. 5.

Shell of medium size, discoid, compressed, whorls about four, contiguous, sides slightly rounded, but narrowly rounded on the dorsum.

Lateral diameter of the whorls, slightly less than the dorso-ventral at the middle of the last volution; width of the umbilicus equal to about once and a half that of the dorso-ventral diameter. The lower margins of the volutions are sharply rounded into the umbilicus.

Septa composed of two rounded lobes on each side with an obtusely pointed projection between them. Surface smooth.

Greatest diameter 1¾ inches; lateral diameter of outer whorl ½ inch; dorso-ventral diameter near the aperture $^9/_{16}$ inch.

Locality and position: This species is represented by a single specimen only, which was obtained from a thin bed of partly brecciated limestone that forms the upper part of the St. Louis limestone near Waterloo, Monroe county, Ills.

Collector, A. H. Worthen.

No. 2589 of the Illinois State Museum.

Genus SOLENOCHEILUS, Meek and Worthen.

Solenocheilus indianense. (sp. nov).

Pl. XXVIII, Figs. 1-1a.

Shell moderately large, sub-globose in form; umbilicus deep and about two-thirds as wide as the dorso-ventral diameter; test thin and without ornamentation.

Septa comparatively wide, two and a half equaling in width the dorso-ventral diameter, the outer ones curving gently forward on the dorsal portion of the shell.

The outer chamber is only partially preserved, but must have measured from seven to eight inches in width when complete.

Siphuncle small and situated near the dorsum.

We have seen but a single specimen of this fine shell, which was obtained from the upper beds of the St. Louis limestone at Greencastle, Indiana, where it was associated with *Temnocheilus coxanum*, *Solenocheilus collectum*, *Orthoceras*, etc.

Collector, A. H. Worthen.

Genus TEMNOCHEILUS. McCoy.

Temnocheilus scottense. (sp. nov.)

Pl. XXVII, Figs. 3-3a.

Shell of medium size, subdiscoidal, sides of the volutions broadly rounded, dorsum nearly flat on the chamber of habitation; and depressed convex on the remainder of the outer volution; volutions about three and a half; umbilicus wide and deep, showing nearly the whole of the second volution; test thin, and apparently without external ornamentation. The outer chamber occupies nearly one-half the outer volution.

Septa arching slightly backward on the sides, and separated on the dorsum, by a space equal to about one-fourth the transverse diameter of the volution.

Greatest diameter of the specimen in hand, 3⅝ inches; transverse diameter of the chamber of habitation, 1½ inches; dorso-ventral diameter of the same $1^{5}/_{16}$ inches.

Position and locality: Warsaw beds of the St. Louis limestone, near Winchester, Scott county, Illinois.

No. 2587 of the Illinois State Museum.

Genus ASCOCERAS. Barrande.

Ascoceras southwelli. (sp. nov.)

Pl. XXVII, Figs. 2-2a.

This rare species is represented by two imperfect specimens only, the one figured being the most perfect of the two in hand. This shows only the chamber of habitation, the form of the septate portion, and the extremity of the siphuncle.

Shell small, cylindrical at the upper extremity, and slightly inflated below, giving it when the septate portion is preserved a slightly ovate outline.

Dorso-ventral diameter a little more than the lateral, and greatest about midway between the two extremities. Septa not preserved but apparently about two. Siphuncle proportionately large, septate, and situated close to the dorsal side.

Length of the best preserved specimen, incomplete at the upper extremity $1^9/_{16}$ inches; breadth of the dorso-central side about midway of its length $^7/_{16}$ inch; breadth of opposite side $^6/_{16}$ inch.

Position and locality: Niagara limestone, Port Byron, Ill.

Collector, J. H. Southwell.

No. 2588 of the Illinois State Museum.

ORDER CRUSTACEA.

GENUS COLPOCARIS. Meek.

COLPOCARIS CHESTERENSIS. Worthen.

Pl. XXVIII, Fig. 2.

Colpocaris chesterensis, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page 3.

Carapace valves, large, elongate, ovate in outline, more than twice as long as high, the widest portion being about the middle; broadly and evenly curved from end to end on the dorsal margin; ventral margin nearly straight for about two-thirds its length, and then gradually curving upward to the evenly rounded anterior extremity.

The posterior extremity of our specimen is broken away so that its form cannot be clearly determined.

Length 2⅝ inches; greatest width, 1 inch.

Position and locality: From the lower division of the Chester limestone, Chester, Illinois.

Collector, A. H. Worthen.

No. 2496 of the Illinois State Museum.

GENUS SOLENOCARIS. Meek.

SOLENOCARIS SANCTI-LUDOVICI. Worthen.

Pl. XXVIII, Fig. 3.

Solenocaris St. Ludovici, Worthen, March, 1884. Bulletin No. 2 of the Illinois State Museum of Natural History, page.

Carapace valves narrow and elongated, the length being equal to about three times the height, probably slightly convex though flattened on the surface of the limestone; dorsal and ventral margins nearly straight and parallel; anterior end curving regularly upward to the dorsal margin; posterior end terminating in an obtuse point, the ventral margin being more strongly curved at both extremities than the dorsal. The surface is covered with round pits which are most numerous and conspicuous near the margins, with traces of delicate longitudinal striæ along the center of the valve when viewed under a good lens.

Length $^{14}/_{16}$ inch; height, $^{4}/_{16}$ inch.

Position and locality: St. Louis limestone, South St. Louis, Mo.

Collector, A. H. Worthen.

No. 2497 of the Illinois State Museum.

PART II.

PALÆONTOLOGY OF ILLINOIS.

SECTION II.

NEW SPECIES OF CRINOIDS AND BLASTOIDS FROM THE KINDERHOOK GROUP OF THE LOWER CARBONIFEROUS ROCKS AT LE GRAND, IOWA.

AND

A NEW GENUS FROM THE NIAGARA GROUP OF WESTERN TENNESSEE.

BY CHARLES WACHSMUTH AND FRANK SPRINGER.

CRINOIDS AND BLASTOIDS.

Quite a number of Crinoids and Blastoids, with one or two exceptions representing new species, have been recently discovered at Le Grand on the Chicago and Northwestern Railroad, a few miles east of Marshalltown, in Marshall county, Iowa. The quarries at that locality have been in operation for many years, yielding a most excellent limestone, in part oolitic.*

The exposure at Le Grand embraces about fifty feet of vertical thickness. The base of the quarries consists of a fine-grained blue sandstone, which has been used for curbing. This is succeeded by about 18 feet of heavy bedded, whitish grey oolitic limestone, containing many shells and remains of fishes. Above this is a succession of limestone beds of about 35 feet total thickness. The lower part is subcrystalline, bedded in layers of moderate thickness. It is succeeded by a fine-grained, brownish or buff magnesian limestone, which at first is somewhat irregularly bedded in rather thin strata, but toward the top occurs in massive layers from 2 to 4 feet thick. Below the heavy beds there are several thin layers of soft, sandy limestone, and these contain the remains of Crinoids in remarkably fine preservation, as the specimens herewith illustrated abundantly show, and they occur in large quantities.

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*The oolitic layers, which are easily cut and polished, have been used ex ensively for ornamental work and heavy masonry. The stone has proved to be a good building material, and its durability is said to be well established by tests of many years. It has outlived the prejudice which arose against it when first brought into use, based upon the tendency of oolite in some other localities to crumble, a fault from which the Le Grand rock appears to be free.

A few Crinoids have been discovered in irregular deposits both above and below this bed, and they are for the most part of distinct species.

Next in order are some thin beds of impure limestone, interspersed with bands of chert, and a thin bed of oolite half way up. They contain fish remains, including some large teeth and fragments of spines of enormous size, and from this portion of the quarry we obtained a Crinoid apparently belonging to the Lower Burlington fauna.

The rocks at Le Grand have long been understood to belong to the Kinderhook epoch, and among other characteristic fossils a few Crinoids had been collected; but it was not until recently that the rich crinoidal bed to which we have alluded was discovered.

Within the last two years fine collections have been made by Hon. Delos Arnold, Dr. N. S. McBride, Dr. N. B. Waters, of Marshalltown, and by one of the authors. The quarries are worked by a company, of which Mr. G. F. Kirby is President, Mr. H. J. Howe, Secretary and Treasurer, and Mr. Gregg, Superintendent. The above named gentlemen have formed a scientific association, which has exclusive control of the collection and disposition of the specimens. It is to their courtesy that one of us is indebted for the opportunity to examine the fossiliferous deposits *in situ*, to study the specimens, and to make some interesting collections for himself. He avails himself of this opportunity to tender to Messrs. Arnold, McBride and Waters his grateful acknowledgments for the invitation to make the excursion with them, to Mr. Kirby for unusual facilities most generously placed at our disposal, and to all these gentlemen for their many acts of personal kindness and hospitality.

The geology of this locality has been very clearly described by Dr. C. A. White, in his Report on the Geology of Iowa, 1870, Vol. I, pp. 196–7, where he points out the relation between the rocks in the neighborhood of Le Grand and Indiantown, and the Kinderhook beds at Burlington. He concludes that the heavy oolitic bed represents No. 6, and the superincumbent strata No. 7, of his Burlington section. We see no reason to differ with the distinguished author in this reference, further than to observe that the upper part of No. 3 of the Le Grand and Indiantown section is, in our opinion, very probably the representative in part of the Lower Burlington limestone. Dr. White, indeed, notes this resemblance in his explanation of the Indiantown section, on p. 196. In the upper layers we found a specimen of *Actinocrinus proboscidalis* which is one of the most characteristic species of the Lower Burlington.

By reference to Dr. White's admirable description of the beds at Burlington, in the Boston Journal of Natural History, Vol. VII, No. II, p. 215, *et seq*, published in 1860, it will be seen that his bed No. 7 is divided into three portions, without, however, any definite line of separation. The lower portion is irregular in character, being partly magnesian limestone, in some places somewhat silicious, in others tolerably pure limestone. The middle portion is a rather pure limestone composed to a great extent of the remains of Crinoids more or less solidly cemented together. The upper portion consists of impure cherty limestones and silicious shales. The division between the lower and middle portions of this bed was taken as an imaginary line between the true Devonian (as these Kinderhook beds were then considered,) and the Carboniferous strata, indicating approximately the limits of the two systems. The middle portion is what has since been known as the Lower Burlington limestone, and the upper portion as the beds of passage into the Upper Burlington. In other words, in practice, all beds below Dr. White's imaginary line are Kinderhook, and all above it Burlington.

Comparing these features with what we have observed at Le Grand, we are inclined to think that the strata from the oolitic bed up to the top of the brown and buff magnesian limestone, represent the lower portion of White's No. 7, and that the thin-bedded cherty limestone above is equivalent to the upper part of that bed; the middle or crinoidal Lower Burlington being feebly developed. This, if correct, would make the Le Grand exposure Kinderhook, as far up as the top of the magnesian limestone only.

Very few Echinoderms have been found in the Kinderhook elsewhere. In the paper above referred to, Dr. White gives a list of the genera discovered at Burlington, in which he notes 5 genera of Crinoids, and one of Blastoids as occurring in the lower portion of bed No. 7, and 3 genera in No. 6. Our observations are to the effect that Kinderhook Crinoids in this region are extremely rare, and that the authenticity of some of the few that have been reported from that horizon since the appearance of Dr. White's paper, is very doubtful.

The Waverly beds in Ohio, which are probably the equivalent of some member of the western Kinderhook, have yielded a very interesting crinoidal fauna, to which in general features the Le Grand crinoids bear a certain resemblance, though no identical species have been observed. Still closer, however, is the resemblance between the Le Grand and Lower Burlington species; but even among them we have not been able to positively recognize more than one or two species characteristic of both beds, besides the specimen from the upper layers to which we have alluded. However, there are several other species which are closely allied, and the same genera occur in both beds; but, as a rule, those from Le Grand indicate in one way or another a somewhat lower state of development. This is most readily observed among the species of *Batocrinus* and *Dorycrinus*, in which some of the generic characteristics are, as yet, partly undeveloped, although the tendency toward them is manifested. It is also shown in *Megistocrinus*, of which both Le Grand species have a subcentral anal opening like the Devonian species of this genus, instead of a lateral one placed within the brachial zone, as in the Burlington species.

It appears that the LeGrand Crinoids were deposited in very quiet waters, and in many cases were imbedded just as they died. They occur in nests or colonies, and the genera and species are commingled indiscriminately. It is therefore a curious fact, that while the specimens of some species are of a pure calcareous composition and of a very light color, those of others, under precisely similar conditions, lying side by side with them, sometimes even with stems and arms intertwined, are harder and of a very dark, brownish grey color. The contrast between some of them, indeed, is very marked, and so far as observed, constant for the species, so as to be quite a reliable character for identification. There are of course intermediate shades of color between the lightest and darkest, but, as a general thing, specimens of the same species have a uniform shade.

The conditions of preservation of the LeGrand Crinoids are such as to give unusual opportunities for examining the stems. We found there a number of specimens having the stems intact almost to the extremities of the roots and cirrhi. The stem in all of them is short—shorter than has generally been supposed to be the case among Palæocrinoidea of this period.

In all species of the Camerata which have come to our notice, the lower portion of the stem is provided with small irregular cirrhi, given off at intervals singly from different sides. In a species of *Graphiocrinus*, however, we found the cirrhi thickly distributed all along the stem from the basals down; and a similar structure we observed in certain species of *Scaphiocrinus* lately found by us in Kentucky. It is also worthy of note that in all our perfect specimens from LeGrand, as in those from Burlington and Crawfordsville, the stem tapers to a fine point, giving off rootlets in all directions, and that there is in no instance any indication of an attachment by the column to a solid substance. Similar observations have been made by us upon detached stems and roots, which at Burlington are found in countless numbers, but among all the specimens which we have examined there were only a few—not a half dozen in all—showing a place of attachment, and in these exceptional cases the stem terminated not in form of a plate, such as we find in the Pentacrinoid larva of *Antedon*, but in a mass of flattened roots. This seems to us of considerable importance as bearing upon the question whether the Palæocrinoids generally were attached permanently, or perhaps in their adult state led a kind of semi-free life, somewhat similar to recent species of *Pentacrinus* (Challenger Report on the Stalked Crinoids, pp. 18 and 19, Pl. 19, Fig. 1.) Taking everything into consideration, it seems to us the numerous small rootlets, spreading in all directions lead to the conclusion that those Crinoids, with but few exceptions, either lived upon a soft oozy bottom, in which they were rooted like plants, or that the rootlets served as an anchor, by which the animal attached itself to foreign bodies.

Since the above was written we have discovered in the main bed at LeGrand another well marked species of *Dichocrinus* and a small species of *Scaphiocrinus*, both new, which remain undescribed.

CLASS PELMATOZOA.

ORDER CRINOIDEA.

SUBORDER CAMERATA.

FAMILY ACTINOCRINIDÆ.

GENUS ACTINOCRINUS.

ACTINOCRINUS ORNATISSIMUS (nov. sp.) W. & Sp.

Pl. XVI, Fig. 9. A specimen with arms, showing the posterior side.

Pl. XVII, Fig. 3. A specimen without arms; anterior view.

This beautiful species has close affinities with *Actinocrinus tenuisculptus* McChesney, from the Lower Burlington limestone, which Hall redescribed in 1860, under the name of *A. chloris*. It has a similar style of ornamentation, and the same number of arms.

In *A. tenuisculptus,* however, the arms are arranged in clusters, the interradial spaces are wide and deeply depressed, and this depression, which extends ventrally to the proximal plates, gives to the calyx a decidedly lobed appearance not observable in our species, neither dorsally nor ventrally. It also resembles *Actinocrinus daphne* from the Waverly group of Ohio; but *A. ornatissimus* has tooth-like processes on the back of the arms, which are wanting both in the Burlington and Waverly species. The specimens are always light colored.

Dorsal side of the calyx somewhat depressed, sides convex as far as the top of the secondary radials, whence they spread more rapidly to the arm bases. Basals short; scarcely notched along the sutures, extending outward and forming a rim.

Primary radials decreasing in size in ascending order, all three wider than high. First radials hexagonal and heptagonal; the second quadrangular with convex sides; the third axillary. Secondary radials 1x10; axillary; supporting the two main divisions of the ray. Each of these plates is succeeded by two pieces, of which only the inner one of each ray bifurcates again, giving off two simple arms; while the outer ones, which are truncate above, support a row of fixed cuneiform brachials. The latter are alternately arranged, and interlock on becoming free. There are six arms to the ray, or thirty in all. Exceptions to this rule are not unfrequent, some of the rays having occasionally five, others seven arms.

Arms long; moderately stout, rounded along the back; their tips curved and folded inwards. They are composed of two series of joints, alternately arranged. About every second to fourth joint of each series is longer and bears a conspicuous tooth-like node, giving two alternating rows of nodes on the back of each arm. The intervening joints are very short and connected vertically by waving sutures. Pinnules closely packed together, contiguous. They are composed of short joints, each one provided laterally with a short, tooth-like projection.

Interradials variable in size; the first comparatively large; occupying fully one-half or more of the interradial space in the dorsal cup, and extending up to the middle of the third radials. The first supports two very small pieces in the second range, succeeded by two still smaller ones, and others which constitute a part of the ventral covering. The ventral side consists of small, irregular pieces, interspersed with larger ones which are tuberculous. The first anal plate is as large as the first radials or larger, and generally higher. It supports two plates which are smaller than the first interradial of the four regular sides. The next row consists of three much smaller pieces, two of them interradials, which enclose a second anal plate, with two small plates above. All succeeding pieces are ventral in position and form part of the anal tube. The regions above the arm-bases are hemispherical, not turbinate as in the allied Burlington species, and the anal tube, at its base, is comparatively small, and apparently short. There are generally also two or three interaxillaries, and frequently a small interbrachial between the arm bases.

Summit plates larger than their surrounding pieces and nodose, but smaller than in allied forms. The central plate and proximals, although distributed with the usual regularity, are comparatively small.

The ornamentation gives to this species a beauty which is not surpassed by any other *Actinocrinus*. The plates of the calyx are comparatively thin, and the suture lines difficult to distinguish; they are not convex, but their surface is marked by a system of sharply elevated, very prominent ridges, passing from plate to plate, meeting in large stellate clusters on the interradial spaces. The ridges follow the middle of the radial series, they are very conspicuous, and pass without interruption, from the basi-radial suture into the arms, increasing a little in width toward the arm bases. There are also bead-like elevations, definitely arranged over the plates, and sometimes surmounting the ridges. The sculpturing formed by this combination of ridges and beads is very remarkable and constitutes a most interesting feature of the species.

Column round, composed of joints alternating in size; edges of the internodal joints sharp, the intermediate ones rounded and crenulated. A similar crenulate structure is found around the projecting rim of the basals, giving it a resemblance to a stem joint.

Geological position, etc.: Kinderhook beds of the Lower Carboniferous, LeGrand, Marshall County, Iowa.

Our own collection.

ACTINOCRINUS NODOBRACHIATUS (nov. sp.) W. & Sp.

Pl. XV, Fig. 5. Specimen with arms, from the anterior side.

Pl. XVI, Fig. 10. Specimen without arms, from the posterior side.

Of the type of *Actinocrinus proboscidalis* Hall, but with a larger number of arms, which are less robust, and ornamented on the back with conspicuous nodes, of which no trace is found in the Burlington species. It also resembles our *A. ornatissimus*, especially in the arm structure, but the nodes are distributed at greater intervals and are longer. The two species also differ in their style of ornamentation. The calyx plates of *A. nodobrachiatus*, are strongly convex, the suture lines deeply excavated, and the radiating ridges which cover the plates are not continuous. The ridges, though generally well defined along the edges of the plates, either disappear entirely in the central portion, or become indistinct even in the best specimens, and appear as if they had been worn off by attrition. The specimens are light colored with a slight brownish tint.

Dorsal side of the calyx bell-shaped, sides moderately convex, spreading on approaching the arm bases. Basals short, expanding into a conspicuous rim with a sharp edge, which projects beyond the limits of the column. Interbasal sutures deeply notched, making the basal disk distinctly tripartite.

Primary radials decreasing in size upward; the first plate as high or higher than wide; the second wider than high, hexangular, exceptionally pentangular, or even quadrangular when not in contact with the interradials of the second range; the third twice as high as wide. Secondary radials 1×2×5, almost as large as the preceding axillaries. There are 1×2×10 tertiary radials; the inner ones axillary, giving off two arms, one from each side; the outer ones truncate; supporting a single arm; thus giving six arms to every ray or thirty to the species, with occasional exceptions. The higher radials retain the embryonic character of arm plates; they are cuneiform, and immediately on becoming free change into two series of transverse pieces.

Arms equidistant, crowded at their bases, and taking an outward direction; they are very long, rounded on the back, tapering upward, the tips deeply infolded, sometimes reaching down to the calyx. They are biserial, the plates of each series united longitudinally by straight sutures. Upon the back of the arms there is a series of large tooth-like nodes, whose sharp points are directed upwards. They are larger, but not so regularly arranged as those of the preceding species, and are farther apart, occurring usually either on the sixth, eighth or tenth joint. These nodes are not confined to one plate only, but generally extend over two or more, sometimes covering even a portion of the vertical suture which unites the two series of the arm. Pinnules long, constructed and arranged as in *A. ornatissimus*.

Interradials five to seven up to the arm bases. The first is hexagonal, in size equal to the second radials. The second and third ranges consist of two pieces, which are comparatively large. First anal plate about the size of the first radials, but angular above instead of truncated. It supports two interradials, succeeded by ranges respectively of three, two and two plates. There is one interaxillary, but no interbrachial piece.

The ventral side is hemispherical, composed of a large number of very small, smooth plates, interspersed with prominent spiniferous ones representing the summit plates. The various summit plates are separated from one another by the smaller pieces, as in *Megistocrinus*, and so are also the different orders of radials, which are represented likewise by spiniferous plates. The central plate forms the base of the ventral tube; the latter is located almost centrally, and does not extend to the tips of the arms.

The surface of the plates on the dorsal side is marked by numerous broad, indistinct ridges, passing singly or in pairs from the middle portions of the plates to adjoining pieces. Those connecting the radials and ascending to the arm bases, are not stronger than any of the others, a character by which this species is readily distinguished from *A. ornatissimus*.

Column round, moderately strong, and composed of alternately large and small joints, rounded at their edges. In a specimen in our collection, apparently of full growth, in which the column is preserved to its termination, it is about fifteen inches long. The upper half of the stem is stouter than the lower half, which ultimately terminates in a sharply pointed root. At the upper end, the nodal joints project largely over the intermediate ones, which are also shorter, but the latter grow gradually in length and width, until at the middle of the stem they equal in size the nodal ones, which appear to be correspondingly somewhat diminished. This change goes on more rapidly toward the end of the stem, where the joints lose that convexity which is so marked in the proximal region, and become uniform. The lower portions of the stem are provided with a few thread-like lateral cirrhi; there are no regular branches such as we find in most of the Burlington species, and we doubt if this specimen, and several others of other groups, occurring in the same locality, were firmly attached when they died.

Geological position, etc.: The same as that of the preceding species.

Our own collection.

ACTINOCRINUS ARNOLDI (nov. sp.) W. & Sp.

Pl. XVII, Fig. 10. A somewhat flattened specimen with arms and column.

Of large size, with long, slender, spreading arms, and fan-like fringes of pinnules. Form of calyx subovoid, gibbous below, somewhat spreading at the arm bases.

Basal disk low, discoid, convex toward the margins, with slightly retreating angles to meet the radials; flattened for the attachment of the column, but without projecting rim.

First primary radials large, heptagonal; second hexagonal, not more than one-half the size of the former; the third still smaller. Secondary radials apparently small.

Arms six to the ray on the anterior side; long, tapering abruptly toward the top and growing very thin. They are composed of a double series of very short interlocking pieces, with waving suture lines. In the lower and middle portion of the arms, every third to fifth arm piece bears on the back, close to the longitudinal suture, a small, sharp, hook-like spine, pointing upward. Toward the upper part, the arms have more or less serrate edges, and the plates overlap each other, forming at the back small, pointed hooks.

Pinnules very numerous, long, slender, and in close contact as if forming a reticulate fringe; each joint bearing a prominent sharp hook, pointing at right angles to the pinnules. These hooks, which run in 8 or 10 regular rows, parallel to the arms, give to the mass of the pinnules, as they lie spread out, a marked reticulate appearance.

Interradials five or more, comparatively large. The first equal in size to the second radials, the two in the second range to the third radials; the succeeding ones comparatively smaller. Azygous interradius unknown and likewise the ventral covering.

The surface ornamentation of this species is different from that of any other with which we are acquainted. The surface of the plates is indented with numerous shallow polygonal pits and short grooves, whose rims, which are somewhat rounded off, connect with one another from plate to plate, and on the same plate, in intersecting wrinkles. There is no very definite arrangement of either pits or wrinkles, but the whole surface has a somewhat irregular cancellate sculpturing, not unlike the appearance of the parasitic *Chætetes.*

Column round, composed of very short joints of nearly uniform diameter so far as we have observed them, and alternating in thickness.

Geological position, etc.: Same as last.

Collection of Hon. Delos Arnold.

Genus MEGISTOCRINUS Owen & Shum.

Megistocrinus nobilis (nov. sp.) W. & Sp.

Pl. XVI, Fig. 6. A large specimen with arms.

Pl. XVI, Fig. 7. Another specimen. Ventral view.

Calyx large, broadly urnshaped, truncate at the bottom, with deep constrictions or depressed areas at the brachial zone between the rays and their divisions. Vault usually but little convex, forming almost a plane, except along the azygous side, which is more or less depressed, while the plates surrounding the anal aperture are slightly elevated. The specimens are of a light grey, intermediate between the lightest and darkest fossils of this locality.

Basals comparatively small, resting within a shallow cavity, produced by the bending in of the lower portions of the first radials. They form a very regularly hexagonal disk, with a conspicuous rim enclosing the upper stem joint. The plates are closely anchylosed, and the interbasal suture but indistinctly visible, while the basi-radial sutures are deeply beveled.

Primary radials large; the first and second hexagonal; the third or axillary one pentagonal. The lower portion of the first radial and the interposed first anal plate somewhat abruptly bent inward to form the basal concavity, while the upper portions are slightly bent upward in such a manner that the calyx rests upon the median portions of the plates. Second radials somewhat smaller than the first, but much larger than the third. Secondary radials 2x2x5, about as large as the preceding axillary. They support upon their nearly truncate upper sides two rows of tertiary radials, of which, however, only the lower ones take the form of radials, the others resemble closely free arm plates.

Arms short, the tips bending inwards; bifurcating soon after they become free, and two or three times above. At their bases in the calyx the arms are very robust, but they diminish in size rapidly from each bifurcation upwards. They are composed of a double series of low transverse pieces, longitudinally arranged, and alternating. The pinnules are closely packed together and composed of short joints.

Interradials 12 to 15 or more up to the arm bases, the lower one as large or larger than the second radials, hexagonal, supporting on its sloping upper sides two plates of the size of the third radials; hexagonal or heptagonal according to whether there are two or three pieces in the third range. The plates of the third range resemble in size the secondary radials against which they rest. They are of large size compared with the plates of the upper ranges, especially those of the equatorial zone, which comprise the fifth and sixth ranges. Axygous interradius much larger than the four regular ones. First anal plate a little higher than the first radials, and narrower. It supports three large plates, and above several other ranges of considerably smaller pieces. There are six or more interaxillaries, the lower one as large as the interradials of the third range, the upper ones like the succeeding interradials.

Vault composed of slightly convex plates, almost of uniform size. Summit plates a little larger; continuous in mature specimens; never separated by the intercalation of small plates. They consist of a central piece and six proximals, of which four are placed over the four regular sides, and two over the azygous one, with a radial dome plate interposed above each of the postero-lateral rays. The arrangement of these plates is not correctly represented in the figure. In two of our specimens, the ventral covering of the arms is beautifully shown for quite a distance. It consists of two rows of rather robust covering-pieces, forming a well defined ridge, and there is at each side of them a some what smaller row of side pieces. These four rows commence at the edge of the vault, being continuous with it, and extend apparently to the full length of the arms. It is the first instance, to our knowledge, that side pieces have been observed in the Camerata.

Column large, round, composed of alternate thicker and thinner joints, with a large pentalobate axial canal, in which the lobes, instead of being rounded, are angular.

Geological position, etc.: The same as in the last species.

Collection of Hon. D. Arnold, and our own.

Megistocrinus parvus (nov. sp.) W. & Sp.

Pl. XV. Fig. 7. A fine specimen with arms and column. (One of the rays has exceptionally but two primary radials.)

A comparatively small species. Calyx bowl-shaped, with convex sides, swelling regularly from the basals up. Arms long. This species differs from the preceding one in the form of its calyx, which is not impressed at the bottom, and in having longer arms and a smaller column. Calyx plates convex, without ornamentation; the suture lines well marked. The only two specimens known to us are light in color.

Basals closely anchylosed, forming a low, almost flat disk. Primary radials large, decreasing in size upwards. Secondary radials 2x2x5, supporting ten primary arms. Arms biserial from their base up, constructed of comparatively long pieces, longitudinally arranged, the plates alternating. The arms are long, heavy, but decrease in size after each bifurcation. The two proximal arm-plates, although regularly interlocking, form generally a part of the calyx. Pinnules rather strong, composed of joints twice as long as wide.

Interradials ten to twelve to each area; the first one as large as the third radials, or larger, the upper ones, which form a shallow impression along the calyx, much smaller. There are two plates in the second range, three in the third, and generally two or three smaller pieces above. Interaxillaries three, small. Azygous interradius much wider, consisting of three large plates in the second range, three or four in the third, with several rows above. The exact position of the anus is not known, but it evidently was not placed laterally, as it cannot be seen between the arm bases. Nothing is known of the construction of the vault.

Column and axial canal small for this genus. The joints near the basals are all large, while further down long and short joints alternate.

Geological position, etc. Same as the last species.

Our own collection.

Genus BATOCRINUS Casseday.

Batocrinus mac-bridei (nov. sp.) W. & Sp.

Pl. XV, Fig. 4. Specimen with arms, column and cirrhi.

Pl. XVII, Fig. 12. Anterior side of another specimen.

Pl. XVII, Fig. 11. A side view of the calyx, from its anterior side.

This is the earliest and smallest known species of *Batocrinus*, but it possesses all the characteristics of the genus. Height of calyx and arms rarely more than an inch. The plates are but slightly convex, and without ornamentation. Dorsal cup subturbinate, broadly truncate at the base, with straight sides to the arm bases. The vault is somewhat lobed, with a conspicuous depression toward the arm bases. The specimens have a brownish color, much lighter, however, than those of *Dichocrinus inornatus* and *Rhodocrinus kirbyi*.

Basals forming a shallow cup, truncated at the lower end, and excavated for the reception of the column. The plates are rounded upon the surface; deeply beveled at the interbasal sutures, forming notches, two of which are occupied by radials, the third by the first anal plate. The upper margins are excavated to receive the lower convex sides of the three other radials.

First primary radials one and a half times as wide as high, the second short, quadrangular, more than twice as wide as high; the third pentangular, not higher than the second but wider. Secondary radials 2x2x5, the upper ones axillary; succeeded by two cuneate fixed brachials, each supporting an arm, giving normally four arms to the ray, or twenty in all. Arms biserial, moderately strong, rounded, the tips slightly incurved and somewhat flattened.

Interradials rarely more than three, sometimes but two. The first one very large, extending to the full length of first secondary radials; those of the second range small. None of these plates connect with the interradials of the vault, except those of the azygous side, and therefore the plates forming the bases of the arms are united laterally. The first anal plate has the form of the first radials, and supports upon its truncate upper side another anal piece, which rests between two large interradials. All three plates are nearly of equal size, and as high, if not quite as wide, as the corresponding single plate of the four regular sides. There are two or three small plates above, and a single piece between the arm bases. The interradials of the ventral side are numerous, small, slightly convex. Ventral tube subcentral, long, slender, extending beyond the tips of the arms. Ventral side broadly convex, somewhat lobed; composed of numerous small convex plates, among which the summit plates are well defined, the central one forming the base of the tube.

Column short, the nodal joints in the upper part large, rounded on the edges; the intermediate joints comparatively small and short, contrasting strongly with the others. At the lower end the joints are more uniform. The column has been observed by us to its full length in several specimens, and in all of them it is short, not to exceed six inches. It tapers all the way gradually to its distal end, where it terminates in a sharp point. The lower part, to about one-third of its whole length, bears short lateral cirrhi, which are arranged singly, not in whorls, there being but one to a joint.

Geological position, etc. The same as the preceding species.

Our own collection.

GENUS DORYCRINUS Roemer.

The three species of *Dorycrinus* herein described are very interesting as illustrating the close affinities which exist between *Batocrinus*, *Eretmocrinus and Dorycrinus*, for which we proposed (Rev. of the Palaeocr., Pt. II, p. 96,) the group Batocrinites. If it was not for the fact that *Dorycrinus immaturus* has but two arms in the anterior ray,* and *Batocrinus mac-bridei* four, the two species could not be easily separated without seeing the posterior side of the calyx and the ventral covering. The azygous interradius is much wider, and in the arm regions forms a large gap between adjoining rays. At the four regular sides, also, the interradials of the dorsal cup are continuous with those in the vault, but the gap between those arms is much smaller. Another small gap is found between the main divisions of the rays; while the two arms comprising each division are laterally connected with one another for quite a distance. The pairs of arms are given off from a small bifurcating radial, each arm having a separate ambulacral opening, but the openings placed closely together. We allude to all these details to show that *Dorycrinus immaturus*, and the two succeeding species from the same horizon, have single arms, contrary to all later species of *Dorycrinus*, in which, as a rule, two arms proceed from one arm opening. The double-arm structure—two arms from one opening—which we have observed only in the Batocrinites, was introduced in the course of time from the single-arm structure, as shown (Rev. of the Palaeocr., Pt. II, pp. 47-50,) in *Batocrinus* and *Eretmocrinus*, in which both forms are found frequently side by side, and accompanied by most remarkable transition forms.

A comparison of the Le Grand species with those in the Burlington and Keokuk limestones, reveals the fact, that the former have but half as many arms as the latter. Among the species of the two beds the arms are distributed fundamentally on the same principle, those, however, of the lower horizon have single arms, while the others have two arms from each arm opening. Another differentiation between the species of the different horizons is shown by the fact that in species of the Burlington and Keokuk the arm joints are extended into lateral spines; while in the Le Grand species the tips of the arms are merely compressed and flattened.

* Since the above was written, we have found in a layer nine feet above the main crinoidal bed a number of specimens of a variety of this species having uniformly four arms to the anterior ray, but otherwise undistinguishable from it.

DORYCRINUS IMMATURUS (nov. sp.) W. & Sp.

Pl. XVII, Fig. 17. Posterior sides of a specimen with arms.
Pl. XVII, Fig. 6. Another specimen, showing anterior side.
Pl. XVI, Fig. 5. The calyx, showing the position of the anal opening.

The specimens are below medium size, measuring from an inch to an inch and a half to the tips of the arms. Dorsal side of the calyx subturbinate with slightly convex sides; the plates convex and without ornamentation. The vault is conical, somewhat flattened posteriorly. Color of the specimens rather dark.

Basals short, truncated, extending laterally beyond the limits of the column; suture lines distinctly defined. First radials comparatively large, almost as wide as high; the lower margins convex, the upper concave; upper corners truncated. Second and third radials very short, not more than half the width of the first, but twice as wide as high; the second quadrangular; the third pentangular. Secondary radials 2x2x5; resembling in form the two upper primary radials, but somewhat smaller. The upper plates are axillary in the four lateral rays, where they support 2x2 tertiary radials with two arms each; in the anterior ray quadrangular, with only one arm to each side, thus giving 18 arms to the species.

Arms biserial, arranged in groups around the calyx, and separated interradially by small plates. There are no inter-axillary plates although the main divisions of the rays are readily identified. The two arms which constitute these divisions are in four of the rays arranged in pairs, being connected laterally by the proximal arm plates.

Interradials three in the dorsal cup, two of them at the brachial zone, and others above. First interradial very large, extending beyond the limits of the third primary radials; twelve-sided, and nearly as wide as high. The two plates above are elongated, small, but larger than those succeeding them in the vault. First anal much the largest plate in the calyx; supporting three plates in the second range, which are nearly as large as the first regular interradials; the middle one, or second anal plate, smaller than the other two. These again are succeeded by several smaller plates forming a protruding subcentral anus which is lateral, but placed above the arm bases.

Vault subconical, pentalobate; summit plates prominent, the central one sharply tuberculous, showing a tendency to become spiniferous.

Column round, composed of long joints with rounded edges, which alternate near the calyx with very short and narrow pieces.

Geological position, etc.: The same as the preceding species. Our own collection.

Remarks: It is possible that this Kinderhook form is specifically identical with *Dorycrinus* (*Actinocrinus*) *helice* Hall from the Waverly group of Ohio.

Dorycrinus radiatus (nov. sp.) W. & Sp.

Pl. XVII, Fig. 5. A specimen with arms from the posterior side.

Pl. XVII, Fig. 5a. The same from the anterior side.

Dorycrinus radiatus somewhat resembles *D. immaturus,* but differs from that species in the arm formula, and in being the only species of this genus which has radiating ridges along the plates. From every first radial two low, rounded ridges pass to the basals, two to the adjoining radials and anal plate, and one to each first interradial. The interradials have nine ridges two connecting with the first radials; two with the second, and two with the third radials, while the remaining three which are smaller pass into the three interradials of the second range. The ridges are well defined next to the margins of the plates, but become indistinct, or disappear entirely, in the middle. Color rather lighter than in the last species.

Dorsal side of the calyx subconical, wider than high, truncate at the base, a little convex along the sides. Basal cup short, broad, with projecting lips, extending in width considerably beyond the limits of the column, and slightly beyond the lateral walls of the calyx.

First radials somewhat lower than those of the preceding species, the second and third radials proportionately a little higher. The secondary radials vary among the rays, consisting in the anterior ray, which has but two arms, of two comparatively large, transverse pieces, which are succeeded by free, cuneiform plates, interlocking, and gradually turning into two series of transversely arranged arm pieces. The other four rays have three arms each, with, exceptionally, four in one posterior ray. In these rays the upper secondary radial toward the posterior side is an axillary, and supports two arms, that directed toward the anterior side quadrangular, with one arm only. The arms are scarcely as long as those of the preceding species; they are round and composed of medium sized pieces, with straight transverse sutures.

The interradials dorsally consist of six to eight plates in three ranges. The first plate is large, and extends to the top of the third radials. There are three much smaller plates in the second range, and two in the third, the latter resting between the arm bases. At the azygous side, the plates are arranged as in *Dorycrinus immaturus*. The first anal plate is as large as the first radials, and the three succeeding plates fully equal in size to the single plate at the four regular sides. The second anal plate extends in height slightly beyond the level of the interradials adjoining it, and is generally a little larger throughout. This row is followed by several rows of smaller plates, which lead to a subcentral anal opening. The arrangement of the plates forming the vault is not known.

Geological position, etc.: The same as the preceding species.

Our own collection.

DORYCRINUS PARVIBASIS (nov. sp.) W. & Sp.

Pl. XVII, Fig. 7. Specimen with arms from the anterior side.

Pl. XVII, Fig. 9. Lateral aspect of the calyx.

Pl. XVII, Fig. 9a. The same specimen, showing the ventral surface.

This species differs from the two preceding in the form and proportionate size of the basals, and in the form of the calyx. It is of the type of *Dorycrinus concavus* from the Lower Burlington limestone, for which Meek and Worthen in Vol. II, of this Report, p. 214, proposed the genus *Cœlocrinus*. This species was supposed to have no secondary radials, and upon this character principally, and a slight variation in the arrangement of its interradial and anal plates, the new genus was founded. With regard to the absence of secondary radials, Meek and Worthen were evidently misled. On page 214, they say: "there

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being but a single brachial piece to each division of the ray, soldered into the walls of the body, and these rest directly upon the third radials." What else could these plates be but secondary radials?

General form, without the arms, oblate-spheroidal, truncate below. Dorsal cup in form of a basin which rests upon the basals and portions of the first radials; wider than high, and spreading but little at the sides. Plates moderately convex, without ornamentation, suture lines well defined, with a small pit at each angle of the plates. In color not distinguishable from *D. immaturus*.

Basals forming a very small disk, resting in a shallow concavity, not visible in a side view. First radials large, heptagonal, narrow below and wide above, so as to present an obtusely triangular aspect; the upper corners truncate; upper margins concave to receive the second radials. Second and third radials small, of about equal size. Secondary radials 1x2x5, succeeded in the three anterior rays by fixed brachials. In the posterior ray toward the anal side the secondary radial is axillary, supporting two rows of arm plates, thus giving twelve arms to the species.

Arms biserial, with one or two cuneate joints succeeding the radials, of which those of the same ray are laterally united. The arms are proportionally more robust than in the two preceding species, and resemble those of *Agaricocrinus*.

Interradials in three ranges; the first very large, reaching to the top of third radials. It supports two long, narrow plates, which extend to near the arm-bases, and by still smaller plates in the vault. First anal plate larger than the first radials, hexagonal, higher than wide; the second anal, and the two interradials on either side of it, about equal in size to the first regular interradial. They are followed by about four ranges of small plates, which lead to a circlet of very minute pieces, surrounding a subcentral protuberance with a small lateral opening.

Ventral side depressed, convex, summit plates nodose and prominent; the central one large and projecting, in form of a small spine; the four regular proximals much larger than the two at the anal side, which are separated from the former at each side by a radial-dome-plate.

Column round, slender; composed near the calyx of alternating joints, the larger ones with rounded edges.

Geological position, etc.: Same as preceding species.

Our own collection.

FAMILY RHODOCRINIDÆ.

GENUS RHODOCRINUS.

RHODOCRINUS KIRBYI (nov. sp.) W. & Sp.

Pl. XV, Fig. 10. A specimen with infolded arms, and column.

Pl. XVI, Fig. 3. Another specimen with spreading arms, showing the pinnules.

This species is characterized by its barrel-shaped calyx, robust arms for the genus, short arm joints, and rapid widening of the arm bases up to the first bifurcation. The color of the specimens is very dark.

Calyx elongate, truncate below; the sides nearly straight, swelling but little from the lower edge of the basals on which it rests to the top of the third radials, above which it contracts rapidly, producing the form of a barrel. Some specimens are almost cylindrical, about equal in diameter at top and bottom. Viewed from above or below, the outline is obscurely pentagonal.

Base sharply impressed. Underbasals small, resting in a shallow concavity concealed by the column. Basals very large, their lower margins sharply bent inward, forming the edge of a rim on which the cup rests. Sutures distinct.

First primary radials much smaller than the basals; the second and third about half as large as the first, and equal to each other. Secondary radials 2x2x5, quadrangular, narrow, rising above the surface in prominent ridges, which increase in width upward. They are succeeded by three very short, transversely arranged brachials, which also successively widen upward. The upper one is axillary, giving off two branches. The inner branch of the rays bifurcates again, generally on the third plate, thus giving three arms alternately arranged to each main division of the ray, thirty in all, with occasionally an additional one in one or both posterior rays. The arms are proportionately heavier than in other species of the genus, but taper rapidly at their tips. They are composed of a double series of very short interlocking pieces, with deeply indented suture lines so as to give to the back of the arms a file-like appearance. Pinnules strong, continuous, composed of elongate joints.

Interradials 7 to 9 in four or five ranges; the first plate smaller than the first radials. This is succeeded by two, rarely three, plates of nearly the same size, and two or three ranges of smaller plates. Azygous interradius wider and easily distinguished. It has always three plates in the second range, of which the middle one is an anal, higher than the first radials and fully as wide. There is a second anal plate in the third range, which is but little more than half the size of the first. Succeeding plates small and more or less irregular. Anal aperture placed at the end of a very short, wart-like, somewhat tubular and almost central protuberance, which is directed upwards, and surrounded by small spiniferous plates. The plates at the azygous side are similar in proportion but greater in number than at the other sides. Vault slightly elevated and rounded, with small depressions toward the interradial spaces. It is composed of numerous, very small tumid pieces, among which the summit plates are with difficulty distinguishable.

Surface of plates convex or slightly angular, covered with ridges passing from plate to plate. The ridges following the radials pass into the arms, growing sharper and higher on approaching the arm bases.

Column large, round, joints short, of uniform diameter; central opening small, round or obscurely pentagonal.

This is one of the most characteristic species of the Le Grand beds, and we take pleasure in naming it in honor of G. F. Kirby, Esq., of Marshalltown, Iowa, the President of the Le Grand Quarry Co.

Geological position, etc.: Same as the last species.

Our own collection.

RHODOCRINUS NANUS Meek and Worthen.

Pl. XVI, Fig. 4. Specimen with arms from the anterior side.

Pl. XVII, Fig. 15. Another specimen from another side.

1866, Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 254.

1868, Geol. Surv. Ill., Vol. III, p. 476, Pl. 18, Figs. 2 a, b.

This species was described by Meek and Worthen in Vol. III, of these Reports, p. 476, Pl. 18, Fig. 2 a, b, from a single specimen without arms. It was found by one of us in the Kinderhook beds near Burlington, just above the oolitic layer, but by mistake it was stated in the description to be from the Lower Burlington. It remained unique until the Le Grand discoveries brought to light a number of specimens, which apparently belong to the same species, and as they present the characters of the species more fully, we have thought it best to redescribe it briefly.

Rhodocrinus nanus is nearest allied to *A. kirbyi*, from which it is distinguished by its more globose form, more slender arms, and these composed of longer and more uniform pieces, as well as by the ridge-like series of anal plates. In the Le Grand beds this species is readily identified by its color, which is invariably light.

Calyx subglobose, sides regularly convex, except in specimens with protuberant basals, in which the sides are nearly vertical. Base truncate, slightly impressed.

Underbasals small, projecting but little beyond the column. Basals large, sometimes protuberant, the cup resting on their lower edges, which are rounded and form a low rim around the shallow basal depression.

First primary radials nearly as large as the basals; second and third about equal, and one-third the size of the first radials. Secondary radials 1x2x5, followed by about five rounded quadrangular brachials of uniform size.

Arms bifurcating on the fifth joint, and the inner branches of the ray once again on the third joint, with an occasional bifurcation of the outer branch in a posterior ray, giving normally 6 ultimate arms to the ray, or 30 in all. The free arms are biserial, slender, tapering very gradually; the arm pieces proportionately longer and narrower than in *R. kirbyi,* and the back of the arms more rounded and smoother. Pinnules strong, not so closely packed as in the last named species.

Interradials 8 to 10; the first one half as large as the first radials, and the two in the second range almost equaling it in size. There are several more ranges of plates above, which are irregularly arranged and decrease in size upwards. The anal interradius is wider. It contains a row of anal plates, longitudinally arranged, which rest upon the truncate upper face of the first interradial, and extend up to near the anal aperture, forming a kind of ridge, which is readily distinguished from the surrounding slightly depressed interradial plates. The first anal plate is as large as the first radials, the interradials on either side of it smaller than the corresponding plates at the four other sides. Anus excentric, protuberant, tube-like, composed of rather large plates; opening directed upwards.

Ventral side rising somewhat above the dorsal cup, depressed in the interradial spaces, and composed of small, irregular convex pieces. Summit plates very indistinct, if represented at all.

The surface of the calyx is marked by rounded radiating ridges, which are continuous along the radial series, and extend into the arms. The ridges vary somewhat in prominence among specimens, and in some are almost entirely confined to the radial series, giving to the calyx a pentagonal outline; while in others they also pass to the basals, interradials and anals. The plates as a rule are convex, and the suture lines well defined.

Column small, round, composed of alternate joints; perforation small, apparently round.

Geological position, etc.: Kinderhook beds of the Lower Carboniferous, Le Grand; also, Burlington, Iowa.

Our own collection.

RHODOCRINUS WATERSIANUS (sp. nov.) W. & Sp.

Pl. XVII, Fig. 16. Specimen with arms. Anterior view.

This species is of the type of *R. wortheni* Hall, (Geol. of Iowa, 1859, Vol. I, Pt. 2, p. 556), which is its nearest congener. It differs from that species in its more concave base, the proportionally smaller size of basals and first radials, and in its globose form. All specimens known to us are light colored.

Calyx globose, truncate below, and slightly concave. Plates decreasing in size from the basals up. The underbasals are small and concealed by the column. The basals moderately large; their lower end abruptly deflected inward, forming the rim of the basal cavity on which the cup rests.

First primary radials slightly smaller than the basals. Second and third plates still smaller, decreasing gradually upward. Secondary radials 1x2x5, not more than half the size of the third. They support a series of slightly cuneate arm joints, the fifth of which is axillary. In the type specimen, and the most of those observed, there is but one bifurcation, giving four ultimate arms to the ray, or 20 in all, but we have observed specimens, probably more mature, but otherwise not distinguishable, which have five arms in place of four.

Arms rounded, slender, tapering gradually, the joints proportionally longer and narrower than in *R. kirbyi*, and the pinnules stouter. The interradial areas are not depressed, but form an even surface with the other calyx plates. They are composed of about six plates, of which the first is a little more than half the size of the first radials, the succeeding plates decreasing in proportion to their rank. Azygous interradius occupied by a median series of three or more comparatively large anal plates, which are hexagonal, and bordered by interradials of about the same size as the corresponding ones in the other areas. They are succeeded by smaller plates extending up to the anal opening, which is small, subcentral, protuberant, and directed upward.

Ventral side convex, abruptly constricted above the arm bases, with no marked depressions in the interradial spaces. It is composed of numerous small, smooth plates.

Surface of the plates granular, but otherwise devoid of ornamentation; suture lines indistinct.

Column small, rounded, with a small axial canal. The specific name is in honor of Dr. W. B. Waters, of Marshalltown, Iowa.

Geological position, etc.: Kinderhook beds of the lower carboniferous, LeGrand, Iowa.

Our own collection.

FAMILY PLATYCRINIDÆ.

GENUS PLATYCRINUS.

PLATYCRINUS SYMMETRICUS (nov. sp.) W. & Sp.

Pl. XV, Fig. 8. Specimen with arms, column and root.

This species is of the type of *P. burlingtonensis* O. & Sh. (Geol. Surv. Wisconsin, Iowa and Minnesota, 1852, p. 589,) and may possibly be identical with some one of the various smooth species that have been described from the Burlington limestone. Several of these species were based upon specimens in which neither the vault nor the arms were preserved, and from the meagre information we obtain from mere descriptions of the basal and first radial plates, it is not easy to identify them satisfactorily. Our species differs from the *P. burlingtonensis*, as described by Owen and Shumard, in having a proportionally smaller basal disk, longer and narrower first radials; and from specimens identified by the Burlington palæontologists as representing that species, it differs in the form and structure of the ventral side, which in all Burlington specimens is considerably elevated above the arm bases, and occupied chiefly by the extremely large summit plates and the base of a large anal tube. In *P. symmetricus* the ventral covering is low, to a large extent formed by rows of rather prominent covering plates, and the anus is represented by a simple subcentral opening. It agrees with *P. burlingtonensis*, however, in having thirty arms. From *P. pileiformis* Hall, it differs in the vault structure, in its truncate base, and, besides, that species, as shown in our collection, has but twenty, and much heavier arms. The new species bears a strong resemblance to an undescribed species from the Lower Burlington limestone of New Mexico, not only in the shape of the radials, but also in the proportionate size of the basal disk, and the outline of the calyx generally. It agrees in a marked degree with *P. truncatulus* Hall, from the Lower Burlington, described in the Report on the Geology of Iowa, 1858, Vol. I, Pt. 2, p. 538, and we should regard the two as identical, if it were not for the fact that Hall's species has three primary radials instead of two, as all other known species of the genus with the exception of one from the Devonian, of New York. This feature was indicated by Hall—Iowa Report, *supra*—who described the second radial as of "quadrangular form, with a single groove on the inside, showing that there was no bifurcation from this plate." This was so great a departure from the normal type of the genus, that we regarded it as an aberrant individual until recently, when we obtained two specimens of that species with parts of the arms preserved, which have a quadrangular second and pentagonal third primary radial in every ray. This character being thus apparently constant for the species, the LeGrand form cannot be referred to it, and must be regarded as distinct.

The color of the specimens is very light, in marked contrast with *Rhodocrinus kirbyi* and *Dichocrinus inornatus*.

The species is of rather small size, its general form more elongate than discoid; the rays rising vertically in symmetrical clusters, by equal divisions, from the upper portions of the first radials.

Calyx cup-shaped or subturbinate, spreading uniformly to the top of the cup; truncate below, with a slight elevated rim for the attachment of the column; plates convex; interradial and basi-radial sutures beveled and indented. Basal disk small, convex, margins slightly concave, the plates so closely anchylosed, that no traces of sutures can be discovered.

First radials a little higher than wide, increasing in width upward; articular facets facing upward, and occupying a little more than one-third the width of the plate. Second radials triangular, sometimes pentangular, completely filling the facet.

Arms given off from the second plate above the second radial, and on the inner branches again from the second plate above, making six arms to the ray in equal divisions, or 30 in all. Two or three joints above the last bifurcation are usually cuneate, in single series, and above these the arms are biserial, rounded, slender, tapering gradually to the tips. Pinnules strong, not in very close contact.

Interradial plates of moderate size, resting on the corners of the first radials. Anus in form of a simple subcentral opening in the vault. The opening is very small, surrounded by a number of minute plates.

Vault depressed-convex, composed of small, smooth plates. It is conspicuously marked by five strongly elevated ridges, radiating from the center to the armbases. They are composed of small covering plates, which in the two posterior rays extend to the central plate, but in the others rest between the proximals. There are two proximals at the anal side, but apparently no special anal plate, or, if present, it is not distinguishable from the other small plates bordering the anal opening. Nearly the same structure is found in a specimen of *P. truncatulus*, in which two of the rows of covering pieces, at least, extend to the central plate.

Column short, large, rapidly twisted, composed of transverse elliptic joints, as usually in the genus. It tapers to a point, and near the end is provided with numerous short rootlets; which taper in a similar manner. Perforation minute.

Surface of plates and arms smooth, without any ornamentation.

Geological position, etc.: Kinderhook beds of the Lower Carboniferous, LeGrand, Iowa.

Collection of Wachsmuth and Springer.

PLATYCRINUS PLANUS Owen and Shumard (?).

Pl. XVI Fig. 8. A specimen with arms.

1850, Journ. Acad. Nat. Sci. Phila. (Ser. II.), Vol. II, p. 573.

1852, U. S. Geol. Surv. Wisc., Iowa and Minn., p. 587, Pl. 5a, Fig. 4.

1858, Hall, Geol. Surv. Iowa, Vol. II, Pt. II, p. 533.

1868, Meek & Worthen, Geol. Surv. Ill., Vol. III, p. 467.

1873, Meek & Worthen, Ibid, Vol. V, Pl. III, Fig. 5.

The specimen figured under the above name belongs to a type not uncommon in the LeGrand beds. It is larger and more elongate than the preceding species, and characterized by a rather low, gently swelling subturbinate basal disk, above which the calyx is nearly cylindrical, expanding a little at the arm bases. The first radials are a third longer than wide, and their upper margins generally of equal height, forming a straight transverse line all around, without any truncation of the corners for the interradial plates. The articular facet is small, rather shallow, facing upward, without any prominent rim.

Arms usually six to the ray, with some exceptions; long, comparatively strong and with closely packed pinnules. The plates are smooth and thin, sutures not indented. The basal disk has a sharp prominent circular lip for the attachment of the column, forming a part of the basal cup, although having the appearance of an anchylosed upper stem joint. The basal cup appears as a single plate, no traces of sutures being visible. Vault unkown. Specimens all light colored.

The specimen figured is of about medium size, some being considerably larger, others smaller. It has only 5 arms in three of the rays, and the upper margins of the radials are not so uniformly rectilinear as in most of the others, but otherwise it fairly represents the form herein described.

Whether this is really *P. planus* is uncertain. The difficulty arises from the confusion in which the literature of that species is involved. Owen and Shumard described it in the report on the Geology of Wisconsin, Iowa and Minnesota, p. 587, from the Lower beds at Burlington as a thin plated, elongate species, with subturbinate base, long radials with small and deep articular facets, and the point of attachment for the column slightly excavated. They figure on Pl. 5a, Fig. 4, two specimens; one of moderate size answering the description fairly well except that there is no excavation for the column; the other of a very much larger form, which has been described by Prof. Worthen as *P. pratteni*. They also speak of specimens having been seen nearly two inches in diameter, which would be an extraordinary size for any Lower Burlington *Platycrinus*. Hall, in the Report on the Geology of Iowa, 1858, Vol. II, Pt. 2, p. 533, Pl. 8, Fig. 6, figured and described the species with some doubt as to the specific identity of his specimen. His figure shows very plainly that he was describing a specimen of *P. halli* Shumard, from the Upper Burlington, a very different form, with heavy plates and somewhat indistinct surface markings. Meek and Worthen, in Vol. III of this Report, p. 469, Pl. XVI, Fig. 6, described and figured as *P. planus* a well preserved specimen with large, elongate calyx, of the form of *P. pratteni*, having similar slender arms; and again in Vol. V, Pl. III, Fig. 5, they figured under the name of *P. planus*, but without description, a good specimen having many characters in common with the form under consideration. The truth is, there are probably several species of these elongate smooth forms of *Platycrinus*. The plates of those in the Lower Burlington are very thin and fragile, so that specimens in good preservation are rare, and the vault is for the most part unknown. More abundant collections will no doubt throw new light upon their affinities, but for the present we are inclined to think the form herein illustrated comes as near to the original description of Owen and Shumard as any that have since been referred to it.

Geological position, etc.: Same as the last species. Our own collection. *P. planus*, as recognized by the Burlington Geologists, is a leading fossil of the Lower Burlington limestone, and has been found at the various localities where that formation is exposed. It has been collected by us in New Mexico, and we have seen specimens from different places in Missouri.

Genus DICHOCRINUS.

Dichocrinus inornatus (sp. nov.) W. & Sp.

Pl. XVI, Fig. 1. A specimen with arms, showing the posterior side.

Pl. XVI, Fig. 2. The same from the anterior side.

This is the earliest *Dichocrinus* known to us from America, and perhaps precedes any known from Europe, but nevertheless it has all the characteristics of the genus. *Dichocrinus inornatus* probably has its closest affinities with *D. ovatus* O. & Shum., which, however, is beautifully ornamented, the calyx, and especially the radials, are more elongate, and the large anal plate less constricted between the arm bases. It also resembles *D. simplex* Shum., but the proportions of the plates in the two species are very different, the basal cup in our species occupying one-third the height of the calyx, besides being deeply excavated for the reception of the column. *D. inoratus* is a very characteristic fossil of the locality, and is found in excellent preservation. The color of the specimens is very dark.

Height of specimens, without the stem, ranging from an inch and a quarter to two inches and a half in the larger ones. Calyx subglobose, truncated at the arm regions; the sides curving very uniformly from the column to the arm bases. Larger specimens comparatively more elongate than smaller ones. Surface of plates devoid of ornamentation or any kind of markings, except the first radials have a small angularity following the middle portion of each plate in a vertical direction, which extends frequently into the basals. Sutures, although quite distinct between the radials, not marked by indented lines.

The basals occupy fully one-third of the height of the calyx; they form a rounded cup or basin, which, seen from above, has a strictly hexagonal outline. Interbasal suture passing from the posterior to the anterior side; frequently obscure.

First radials one-quarter to one-half higher than wide. Sides slightly contracted at both ends, somewhat bulging at their middle portions, and abruptly inflected toward the vault, which, including the first interradials, lies in a plane at right angles to the sides of the calyx. Facets for the attachment of the higher radials above one-third the width of the plates. Second radials small; twice as wide as high or even wider; upper and lower sides convex; rounded like arm plates. Third radials a little larger; triangular, bifurcating; upper angle very sharply pointed, and the upper part bent inward so as to separate the two divisions; the sloping sides of the plates concave. The third radials support from each side a short quadrangular piece, which, together with the preceding plates, form a part of the calyx, being connected with their fellows by the intercalation of interradial plates. They are succeeded by a cuneate free plate, and again by two rows of interlocking arm pieces. First anal plate about the size of the first radials, but more strongly inflected towards the vault.

Arms biserial, two to each ray; about twice as long as the height of the calyx or a little more; comparatively stout; gradually tapering to their tips. The arm plates have parallel upper and lower sides, and are of medium height. Pinnules extremely long, rather stout, closely packed together. They are composed of from 10 to 15 cylindrical joints, about three times as long as wide.

Interradials apparently five to each side, all forming a part of the ventral surface, which is flat and placed on a level with the inflected upper edges of the first radials. The first range of interradials consists of three plates, two of them facing the adjoining radial; the third placed between the two others. There seem to be two, perhaps more, small interradials above, meeting with the summit plates. The azygous side apparently has 5 plates in the lower range, the middle one being an anal plate. The summit plates—their exact arrangement could not be ascertained—are scarcely convex, they form together a conspicuous elevation, from which six well defined ridges pass out to the sides; five of them divide again and follow the arms, the sixth one leads to the anal aperture, which is directed upwards and excentric in position. The ambulacral ridges, those leading to the arms, are formed of irregular covering pieces, the anal ridge by numerous convex or wrinkled plates. Between the ridges are six depressions, four of them located above the regular interradii, the two smaller ones above the azygous side.

The column of this species is not very long. From our observation in two specimens it varies from 9 to 10 inches. The joints increase at first a little in width, but soon taper again, until at the distal end the column runs to a fine point, giving off at intervals a small, short cirrhus from one side only. The joints throughout are very even, and the nodal joints can be distinguished only along the upper part of the stem. Axial canal minute.

Geological position, etc.: The same as in the last species.

Our own collection.

SUBORDER INADUNATA.

Branch FISTULATA.

Family POTERIOCRINIDÆ.

Genus GRAPHIOCRINUS.

Graphiocrinus longicirrifer (nov. sp.) W. & Sp.

Pl. XV, Fig. 12. Specimen with arms, from the anterior side.

Pl. XVII, Fig. 14. The same from the posterior side.

This species is of the type of *Graphiocrinus* (*Scaphiocrinus*) *wachsmuthi* (M. & W.), and *Graphiocrinus* (*Scaphiocriuus*) *spinobrachiatus* (Hall), but differs from both in having cirrhi along the upper portions of the stem. Besides, the former has a decidedly bell-shaped calyx—the upper part of the radials flanging outward; also the brachials are much less constricted, the succeeding arm plates considerably higher, and the outlines of the arms less waving. *G. spinobrachiatus* has a more depressed dorsal cup, the underbasals are covered by the column, it has stouter arms, and these are covered with small spines. The specimens are always of a light color.

Calyx short, depressed, saucershaped, with slightly convex sides; scar for the attachment of the column but slightly impressed. Underbasals, although small as in almost every other species of *Graphiocrinus,* extending slightly beyond the limits of the column. Basals large; four of them hexagonal, about as wide as high; that of the azygous side considerably larger and heptagonal, supporting upon its truncate upper face a large anal plate, which extends far beyond the top of the radials, and actually forms a part of the ventral tube. There is no azygous plate.

Radials once and a half as wide as high, and about of equal size, but differing somewhat in form although all are pentagonal; the two facing the anal piece, owing to the greater length of the posterior basal, irregular. The upper face of the radials, throughout the full width of the plates, truncated and slightly concave. Brachials one, of the same height as the radials; pentangular, but subtrigonal in outline, upper angles sharply pointed; line of articulation toward radials and also first arm plates widely gaping.

Arms ten, long, moderately stout, gradually tapering. They are composed of rather short, sharply cuneate pieces, which at the upper margins form a thickened rim, which projects beyond the lower end of the succeeding joint. The rim increases gradually in prominence in the upper parts of the arms, especially at the pinnule-bearing side of the plates where it bulges out considerably, giving to the arms their characteristic zigzag appearance. The proximal arm plates, next to the brachials, are longer than the succeeding ones, at their lower face as wide as these, and somewhat constricted along their middle portions; the others are at their longest side about equal to their width. Pinnules long, and close to the arms very strong. They consist of about ten joints, of which the proximal ones are short, the others from twice to three times their width.

The form and size of the ventral tube is not known, near its base it is composed of longitudinal rows of very regularly arranged hexagonal pieces.

Column small, indistinctly pentangular; nodal joints considerably higher, especially the lower ones, and projecting laterally. Each nodal joint, from the calyx down, gives off radially several cirrhi, which are long, slender and directed upward. Near the calyx where the nodal joints come very close together, the cirrhi are so tightly packed that they frequently hide the column, and extend beyond the calyx to the arms. Farther down the column they are wider apart, and reach a length of an inch and a half or more, while their length above is not more than an inch. They are composed of numerous short joints, and end in a sharp point.

Geological position, etc.: The same as the last.

Our own collection.

Genus SCAPHIOCRINUS Hall (emend. W. & Sp.)

Scaphiocrinus elegantulus (nov. sp.) W. & Sp.

Pl. XVII, Fig. 13. A beautiful specimen with arms and portions of the stem.

This small and elegant Crinoid resembles very closely *Scaphiocrinus nanus* M. & W. from the Lower Burlington limestone, and perhaps should only be considered a variety of that species. The Burlington form, however, differs in having a more depressed calyx, larger underbasals and higher brachials.

The LeGrand specimens are always light in color.

Calyx turbinate, the sides very slightly convex; a little wider than high; without ornamentation. Underbasals projecting beyond the column; the upper angles turned upward to meet the basals. Four of the basals are hexagonal, about as wide as high, the fifth one heptagonal, and larger throughout. Radials but little larger than the basals, and almost as high as wide; the upper face truncated throughout the width of the plates. Brachials one to the ray; axillary; nearly twice as high as the radials; obtusely angular for the reception of the first arm-joints; not constricted in the middle, and, when the arms are closed, their lateral faces almost meeting with those of their fellows from adjoining rays.

Arms dividing once from the brachials up, the division taking place generally from the sixth plate. The arms are comparatively strong, waving in outline, and composed of cuneate, slightly convex and rounded pieces, about as high as wide or nearly so. Pinnules very conspicuous, long, unusally stout, and composed of cylindrical joints twice as long as wide. Azygous side exceptionally wide. The posterior basal extends to one-half the height of the radials, and supports upon its truncate upper side the anal plate, which to a large extent forms a part of the ventral tube. The azygous plate, to the right of the anal plate, is also unusually large, pentagonal, and extends very nearly to the top of the right postèro-lateral radial, although that plate, as in most of the Poteriocrinidæ, occupies a higher level than the radials of the other rays.

The column, as observed in two specimens, is from 4 to 5 inches long. It tapers gradually from the calyx down, and terminates in a fine needle point. It is round, and composed of rather long segments, the nodal joints more prominent. Only the lower portions of the stem, for about two-thirds of its length, are cirrhus-bearing. The joints which bear the cirrhi are higher than the intermediate ones, and while increasing in length they decrease in width downward; the cirrhi are given off singly, and are directed upwards, contrary to those of the preceding species which hang downward; they are long, threadlike and taper at their ends.

Geological position, etc.: The same as that of the last species.

Our own collection.

SCAPHIOCRINUS GLOBOSUS (nov. sp.) W. & Sp.

Pl. XVII, Fig. 8. A specimen of unusually large size.

A small species. Calyx semi-globose; the plates without ornamentation or convexity.

Underbasals minute, resting within a concavity formed by the basals; rounded at their lower end; covered completely by the column. The basals are comparatively large; four of them regularly pentagonal, the fifth somewhat larger and hexagonal, supporting upon its truncate upper face the anal plate.

Radials short, twice as wide as high. Brachials triangular, meeting their fellows of adjoining rays; the two sloping upper sides forming an acute angle; each side supporting from four to six arm-plates of a second order, the upper one axillary. There are two more branches above, making four arms to each ray, the anterior one being not distinct. They are composed of strongly wedge-shaped pieces, slightly swelling toward their larger end; the axillaries more prominent. Pinnules strong; tubular.

Anal plate larger than the azygous piece; ventral sac unknown. Column unusually small, round, its diameter less than that of the arms near their tips.

Geological position, etc.: The same as the last.

Our own collection.

SUBORDER ARTICULATA.

Family ICHTHYOCRINIDÆ.

Genus TAXOCRINUS.

Taxocrinus fletcheri Worthen.

Pl. XV, Fig. 6. A specimen with arms and stem.
Pl. XV, Fig. 9. Another specimen from the posterior side.
1883, Worthen. Geol. Rep. Illinois, Vol. VII p. 308, Pl. XXX, fig. 2.

Of about medium size; rather short for its width; arms stout, short, closely folded together. The nature of the arms, and still more the unusual size of the stem, gives to this species that solid and robust aspect by which it is characterized, and readily distinguished from all other species of this genus. The specimens which we examined are all light in color.

Underbasals entirely covered by the column, and also portions of the basals. The exposed parts of the latter are pentagonal, twice as wide as high, obtusely angular above, except the posterior plate which is slightly truncated. The basals, together with the first and second primary radials, form a conical cup with broadly truncate base.

Primary radials three, transversely arranged, increasing in width upward; their lines of articulation, like those of the succeeding orders of radials and all arm-plates, strongly undulate, with short but wide patelloid pieces* interposed between them. The first and second plates are about twice, and the third three times as wide as high. The third radials, which

*The patelloid pieces, although well defined in the specimens, were omitted in the figures.

are axillary, are sharply angular at their upper faces, and provided with two articular facets and two impressions for the reception of patelloid plates. Secondary radials three; by one-half narrower than the preceding ones, and somewhat shorter, but not in proportion to the decrease in width, except the axillary one, which is comparatively shorter and also wider.

The next order of plates consists variously of from 3 to 5 or 6 pieces, with another bifurcation above. These plates are all arranged on the plan of the primary radials, like them they are flat at their outer sides, and united in a similar manner as those, which makes it difficult to ascertain the actual commencement of the arms. This difficulty is increased by the fact that the rays are free from the top of the primary radials, while their main divisions remain united all along the secondary radials by means of interaxillary plates. Perhaps these rays formed a kind of free appendage like those of the Platycrinidæ and Hexacrinidæ, a question, however, which cannot be solved unless we find the ventral covering intact.

Interradials three; elongate; the two upper ones much smaller, extending to the top of the primary radials. There are generally three somewhat smaller interaxillaries, arranged longitudinally, which unite the secondary radials. Smaller specimens have but one or two. The azygous side is composed of a row of from 3 to 4 or more tube-like anal plates, longitudinally arranged, which rest upon the truncate upper face of the posterior basal. There are no traces of interradials to connect these plates with the radials.

Column extremely stout, almost large enough to support a species of twice the size of this. It is inflated near the calyx, and, along the upper part for about an inch, is composed of rather short, very uniform joints, when suddenly the aspect of the column changes entirely, the joints, at their margins, become more convex, and larger and smaller joints alternate with one another, the larger ones extending conspicuously beyond the smaller ones.

Geological position, etc.: The same as that of the last species. Our own collection.

TAXOCRINUS INTERMEDIUS (nov. sp.) W. & Sp.

Pl. XV, Fig. 11. A fine specimen with arms and stem.

A transition form between *Onychocrinus* and *Taxocrinus*, but apparently nearer the latter; larger than the preceding species; in its usual condition, with the arms bent inward, wider than high. The rays widely divergent; the arms so long that their incurved tips hang down to the top of the primary radials. Color of specimens comparatively light; the plates devoid of ornamentation.

Underbasals three, unequal; the smaller one placed in a vertical line with the right postero-lateral radial; almost completely covered by the column, there being only a small rim exposed laterally.

Basals large, subequal in size; regularly pentagonal; forming a shallow cup, with five salient and five reentering angles.

Radials four in four of the rays, five in the right postero-lateral one (constant in both specimens); wide but comparatively short for the genus, about three times as wide as high, the upper and lower plates somewhat wider and proportionately higher; the axillary one with obtuse upper angles. Secondary radials three, a little more than half the width of the preceding plates; the lower ones laterally connected in the same ray, but not with their fellows of adjoining rays; the second separated by three interaxillaries; the third free, widely apart. Third order of radials variously composed of from 3 to 5 plates, of similar proportions to those of the preceding orders, with one or three small interbrachials between the second plates; the succeeding radials free. There are apparently three more divisions above, the proximal plates above each bifurcation connected laterally, the upper ones free.

All articular lines between the radials of the first and second orders undulating, owing to the presence of short but wide patelloid pieces; the lines between the succeeding plates straight, the patelloid pieces either being absent or very minute.

The interradial plates can be traced in both specimens to the ventral side; they are very interesting as throwing light upon the ventral covering of the Ichthyocrinidæ generally. In four of the interradii, interposed between the primary radials, there are five to seven comparatively large, slightly convex plates variously arranged; the lower one which is larger generally deeply wedged in between the first radials, so as to almost touch the upper angles of the basals. There are two, three or four plates in the second range, which abut laterally against the adjoining second and third radials, and these are succeeded by 4 or 5 plates of a third row, which are abruptly bent inward at their upper ends almost at right angles, so as to form a sharply defined edge, against which the plates of the ventral covering rest. The latter plates are very minute and irregular in their arrangement, they form a pliable integument, which probably extends over the whole surface and along the rays. The free rays at their ventral side are provided with large pouches which apparently contain the ambulacra. At the azygous side the arrangement of plates is very different; the posterior basal is shorter, truncated instead of angular, and excavated at the upper end for the reception of three or more anal pieces, which are longitudinally arranged and connected with the radials at each side by small plates.

Column stout; slighely tapering; its upper end composed of very short and even joints, all of equal size and prominence.

Geological position, etc.: The same as the last.

This is probably the rarest species at LeGrand, only two specimens having been found; that figured is from the collection of Hon. Delos Arnold, the other in our possession, being kindly presented to one of us by Mr. George Cull, the station agent at LeGrand.

CLASS PELMATOZOA.

ORDER BLASTOIDEA.

FAMILY CODASTERIDÆ.

GENUS OROPHOCRINUS.

1864. *Orophocrinus*, Von Seebach, Nachr. k. Gesellsch. zu Göttingen, p. 100.

1879. *Orophocrinus*, Zittel, Handb. d. Palæont. I, p. 434.

1882. *Orophocrinus*, Ether. and Carp., Ann. and Mag. Nat. Hist. (Apr., 1882), p. 249.

1883. *Orophocrinus*, Ether. and Carp., Ibid. (Apr., 1883), p. 226.

1885. *Orophocrinus*, Wachsmuth, Geol. Rep. Illinois, Vol. VII, p. 347.

1886. *Orophocrinus*, Ether. and Carp., Blast. Catalogue, p. 283.

Syn. *Pentremites*, (in part) Münster, 1839, Beiträge z. Petrefactenk, p. 1; also DeKoninck and Lehon, 1853, Recherch. sur les Crin. du Terrain Carb. de la Belgique, p. 189; also Owen and Shumard, 1852, Geol. Rep. of Wisc., Iowa and Minn., p. 393.

When Meek and Worthen, in 1869, proposed the name *Codonites* for Owen and Shumard's *Pentremites stelliformis* and their new species *C. gracilis*, they were not aware that Von Seebach had previously proposed for the former the genus *Orophocrinus*, which, having priority, must be accepted. Since then Etheridge and Carpenter have placed under *Orophocrinus* several European species, which had likewise heretofore been referred to *Pentremites*.

OROPHOCRINUS CONICUS (nov. sp.) W. & Sp.

Pl. XV, Fig. 1. Specimen with the pinnules and part of column preserved.

Pl. XV, Fig. 2. Another specimen, profile view. Enlarged two diameters.

Pl. XV, Fig. 3. The same specimen from the ventral side. Enlarged as above.

This and the succeeding species are readily distinguished from all other known species of this genus by their more slender form, resembling therein *Troostocrinus* and *Metablastus*. *O. conicus* differs from *O. fusiformis* in the form of its ventral side, which is hemispherical, in the latter conical. Besides it has shorter ambulacra, and a less number of pinnules.

O. conicus has the form of an elongate inverted cone with nearly straight sides; ventral side depressed, hemispherical. Surface of the plates smooth, or in well preserved specimens marked by indistinct concentric lines around the plates. Basal portions occupying more than two-fifths of the general height of the calyx, or fully one-half the length up to the radial lips. Neither the interbasal nor basi-radial sutures are marked by any sort of identation, and both are therefore rarely observed; The interradial sutures, however, are slightly depressed, especially along their upper portions, where they form an obtuse retreating angle, thus giving to the section across the lips an obscurely stellate outline.

Radials or forked plates almost twice as wide as high; their lateral faces nearly parallel; the lower sides in the three plates facing the interbasal sutures angular, in the two others rounded. The limbs of the radials extend to about one-half the length of the ambulacra; they bend inward, and leave a comparatively wide radial sinus.

The interradials or deltoids are partly visible in a side view; they are double-diamond shaped, constricted along the middle, so as to appear almost like two separate plates. The plate at the azygous side is slightly bulging, pierced by a large elliptic anal aperture, which in three of our specimens is completely closed by a disk, composed of a large number of very minute irregular pieces, which rest somewhat deeper than the surrounding plates, leaving no trace of an opening. The oral opening is sharply pentangular and moderately large—much larger than in *O. stelliformis*. It is covered in perfect specimens by comparatively large, very regularly arranged summit plates, consisting of a central piece, and four large and two smaller proximals, from which irregular rows of covering pieces extend to the ambulacra, arching over the food groves.

Ambulacra short, more or less petaloid, only partly visible in a side view. They extend laterally to the slit-like openings or clefts, and present an even surface with the surrounding calyx plates; being neither elevated nor depressed. The lancet piece extends to the sides of the radial sinus; it is rounded along its outer face, forming a longitudinal groove at each side, at the bottom of which the clefts are placed. The lancet piece is completely covered by the side pieces, which embrace the food grooves, except near the oral center, where the grooves grow deeper and are placed between the edges of two adjoining deltoids. There are about fifteen side pieces to each side of the ambulacrum, and an equal number of pinnules, but no pores exist along the sides. The clefts are formed between the ambulacra and the constricted portions of the deltoids, and hence do not extend to the full length of the ambulacra. The clefts are wider at their proximal end, and slightly curved, which gives to the ambulacra their petaloid form, The pinnules are longer than those of any previously described Blastoid, their length being twice that of the calyx. They are of uniform thickness throughout, and composed of two rows of pieces, alternately arranged. Their ventral furrow is wide and apparently covered by small plates.

The column has been observed by us to a length of seven inches, and was apparently much longer. It is stout close to the calyx, whence it tapers rapidly; afterwards it remains nearly uniform, with a few scattering cirrhi toward the end. The stem joints at the upper end are extremely short, with a very sharp edge, but they gradually grow longer and cylindrical.

Geological position, etc.: The same as the last.

From our collection.

Orophocrinus fusiformis (sp. nov.) W. & Sp.

Pl XVII, Fig. 4. A fine specimen having its pinnules preserved, and portions of the stem.

Calyx elongate, biturbinate. Dorsal side up to the radial lips, longer than wide; angular radially; the sides undulating; the lips projecting. Ventral side, from the radial lips upward, nearly as long as the dorsal, but the sides convex, curving gently. Cross section through the radial lips decagonal, with five salient and five retreating angles, and this is the case, to a less extent, from the deltoids down to about half the height of the basals, giving to the species an angular outline, by which it is readily distinguished from *O. conicus*.

The surface ornamented with delicate concentric lines, finer than those of the preceding species. The specimens are light in color.

Basals nearly as high as the radials to their lips; forming jointly a subconical cup with slightly convex sides; angular above for the reception of the radials; two of the upper faces moderately concave, the other three angular.

Forked plates or radials elongate; the prongs or limbs nearly as long as the handle or body; width across the lips almost twice as great as at the two ends; the lateral faces as well as their outer face gently and uniformly curving upwards and downwards; the median line toward the sinus somewhat angular; the lips projecting, flanging outward so as to give to the calyx up to the lips a reversed bell-shaped form. The sinus is longer than in the preceding species, increasing in width upward; its edge distinctly beveled. Interradial and basi-radial sutures well defined.

Deltoids long, about as high as the basals, the upper sides deeply constricted near their upper end for the admission of a large spiracle; the lower sides less than half the length of the upper.

Ambulacra long, somewhat wider than usual in this genus; their sides almost parallel except at the distal end. They occupy fully one-half the length of the calyx, and rest deeply within the radial sinuses, which have steep sides, Lancet pieces visible throughout their full length; the exposed part at the proximal end equal to one-third the width of the plate. Food grooves deep, especially near the mouth, however, when closed by covering pieces these form conspicuous ridges, which extend inward as far as the summit plates. Side pieces with a well marked tubercle in the direction of the lancet piece, and superficial grooves toward the pinnules, which rest within shallow pits. The pinnules are composed of single joints, rather flat, scale-like, upper and lower faces undulating. There are ten groups of hydrospires, eight to each group. The spiracles are reduced to an elongate slit-like opening, wider above than below, not visible when the pinnules are *in situ*, but quite conspicuous when these are wanting, large enough that we could observe at the bottom of two of them the clefts of four and six hydrospires respectively. Anal opening very narrow, decidedly slit-shaped, and strictly lateral.

Geological position, etc.: The same as the last.

The figured specimen is in our own collection; the description of the ambulacra and hydrospires was made from a beautiful specimen kindly presented to us by Prof. W. H. Barris, which we received too late for illustration.

March, 1887.

P. S. This paper was placed in the hands of Prof. Worthen early in the spring of 1887, before we had made the discovery that the so called "central plate" and the four "proximals" at the summit of Blastoids and Crinoids represent the *orals*, and this accounts for the fact that the old terms are used in the descriptions.

A NEW GENUS FROM THE NIAGARA GROUP OF WESTERN TENNESSEE.

ALLOCRINUS. (nov. gen.) W. & Spr.

Ἄλλος another; κρίνον a lily.

Allocrinus belongs to a group of Crinoids which is sparsely represented in America, but of which several genera and a number of species are known to have existed during the Upper Silurian period in Sweden. It belongs to the *Camerata,* family *Melocrinidæ,* division *Stelidiocrinites.* Its closest affinities are with *Patelliocrinus* and *Dolatocrinus.* It differs, however, from both of them in the form and size of the various calyx plates, in the arm structure, and in the column. The genus is most remarkable for its regularly pentamerous symmetry and uniserial arms.

Generic diagnosis. Calyx small; the arms very stout. Symmetry of the dorsal side strictly equilateral. Basals probably three; small; almost completely covered by the column. Primary radials 3x5; the first very large; the other two much smaller, rounded along their outer face so as to appear like arm plates. Secondary radials two or three; rounded; quadrangular. Arms strong; uniserial; composed of large transverse plates. Interradials two or more, large, deeply impressed between the radials. Column small, round, with a rather small pentangular central canal.

ALLOCRINUS TYPUS (nov. sp.) W. & Sp.

Pl. XIV, Fig. 7. A specimen with arms.

Pl. XIV, Fig. 7 a, b. Calices of the same.

Below medium size. Calyx depressed, very small, without ornamentation; the arms massive, comparatively stouter than those of any other Crinoid known to us. Basals small, almost covered by the column; disk-like, bending neither inward nor outward; suture lines indistinctly marked. First primary radials large, abruptly curved, the lower portions forming an inverted shallow basin, of which the basal disk forms the bottom part. The upper half of the plates is bent upward, and forms, together with the other plates of the calyx, a shallow, somewhat spreading cup with straight sides, resting on the projecting median portions of the plates. The second and third primary radials have almost the form of brachials, but are connected laterally by interradials. They are very short and rest upon the first radials in a similar manner as the *brachials* of the Cyathocrinidæ upon their radials, and, owing to the deeply depressed interradial spaces and the peculiar form of these radials, it looks as if they were free plates.

Arms ten, uniserial; composed of transverse pieces of a similar form but larger than the preceding radials, and like them with parallel upper and lower faces. The arms are much wider midway, than at the two ends, tapering considerably, and uniformly toward the tips, and in the same proportions toward the first radials, where the arms actually commence.

The interradial spaces are deeply depressed; they are composed of two large plates, vertically arranged, of which the first piece is smaller and nodose, and extends to the top of the primary radials, while the other rests between the secondary radials and forms, to some extent, a part of the ventral surface. There is no anal plate, and nothing is known of the anal aperture nor of the summit structure.

Column small, round; axial canal pentangular, the angles directed interradially.

Geological position, etc. From the age of the Niagara group of Eastern Tennessee. The original is from the collection of Prof. A. H. Worthen, and was found by him at Clifton, Wayne Co., Tenn.

PART II.

PALÆONTOLOGY OF ILLINOIS.

SECTION III.

American Palæozoic Sponges.

By E. O. ULRICH.

AMERICAN PALÆOZOIC SPONGES.

Although the spongiæ attained the height of their development in Mesozoic and subsequent eras, they were also very numerously represented in palæozoic times, in fact, much more so than is generally known or suspected. As a rule they cannot be considered common fossils, and, generally, belong to the rarities. There are, however, several notable exceptions, such as the *Dictyophyton* layers of the Chemung in New York, the *Astylospongia* beds in the Niagara of Tennessee, and the more recently discovered sponge layer near the base of the Trenton in northern Illinois, which has delivered up to the untiring efforts of Dr. Oliver Everett, of Dixon, Ill, the most varied and interesting collection of sponges so far discovered in America. The author, too, has during the last ten years, diligently searched the lower rocks for remains of these long neglected fossils. The material found was carefully preserved, and, since the publication of Prof. Zittel's system of classification, much time has been spent in the attempt to work out the microscopic structure. Owing to the poor state of preservation, the attempt often proved quite unsuccessful, yet on the whole the results were satisfactory. They seem to establish, that the material at hand from horizons below the Devonian represents no less than thirty-four genera.* Of these, twenty-two have been described: *Protospongia* by Salter; *Archæocyathus*, *Calathium*, *Eospongia*, *Trachyum*, *Trichospongia* and *Aulocopina* by Billings; *Aulocopium* by Oswald; *Brachiospongia* by Marsh;

* Including *Archæocyathus* and *Ethmophyllum*, two genera that may not be true sponges, certain features of their structure, lately pointed out, seeming to indicate a closer relationship with the corals.

Ethmophyllum by Meek; *Astylospongia, Palæomanon* and *Astræospongia* by Roemer; *Hindia* by Duncan; *Pattersonia* and *Dystactospongia* by S. A. Miller; *Leptomitus* and *Cyathophycus* by Walcott, *Astroconia* by Sollas; *Cyathospongia,* by Hall; *Lepidolites,* by Ulrich; and *Climacospongia,* by Hinde. The twelve generic groups remaining, appear to be new to science. No doubt it would have enhanced the value of this report had it been possible to define all of them at this time, but a lack of space, but more especially, the unwillingness to describe them without proper illustration, necessitated a restriction to material occurring within the limits of the State, or contained in the State collection. In consequence, only six of the twelve new Cambrian or Lower Silurian genera are defined in the following pages.*

The Devonian and Carboniferous deposits have been much less carefully searched, but the diversity of the fragments obtained, indicate that these organisms were not less prolific in those ages than in Silurian, Cambrian and Taconic times.

A few introductory remarks upon the preservation, geological distribution, and classification of palæozoic sponges, may prove of interest to students, and it is hoped that our humble efforts to bring this neglected branch of our palæozoic fauna before the scientific world will stimulate other collectors to an appreciation of their value.

PRESERVATION.

The structure of the sponges of the Palæozoic rocks, the same as of those from Jurassic and Cretaceous horizons, was often so much altered during the process of fossilization, that it is sometimes extremely difficult to determine its original nature. The mineral constituents of the spicules are apparently never the same as in the recent state, though the extent of the changes varies greatly. The least alteration is where the originally amorphous silica, or calcite, has been changed into the crystalline form of these minerals. The change most frequently met with consits in the substitution of crystalline calcite for

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* Since writing the above, the author has published descriptions of the other new genera in the April, 1889, number of the "American Geologist." The names applied to them are *Rauffella, Leptopoterion, Heterospongia, Saccospongia,* and *Cylindrocœlia.*

the silica. At other times the silica is replaced by the peroxide of iron, or, more rarely, by iron pyrites. On the other hand, a few instances have been noticed where the original calcite has been completely, or only partially replaced by siliceous material.

Another condition, in which the mineral substance of the sponge has been entirely dissolved and removed, leaving the empty moulds of the spicular mesh in the matrix, is not uncommon, but more frequent in specimens from Upper Silurian than other deposits.

As stated, the most common change in the mineral substance of the sponge skeleton is the replacement of silica by calcite. Examples of this replacement occur in all the great geological divisions, but seem to be confined to calcareous and shaly deposits. The calcite which has taken the place of the silica is crystalline, and probably infiltrated the moulds after the siliceous skeleton was dissolved and removed. When the spicules were large or the spicular mesh not too closely interwoven, the change has been effected without effacing the character of the structure; but where the sponge skeleton was composed of small and closely united spicules, not only the finer details of the skeleton have been destroyed but in many instances the entire internal structure is, if not obliterated, at any rate too undefined to be satisfactorily determined. In no palæozoic sponge have I been able to distinguish the canals of the spicules, and in but few instances their method of union, but usually have had to rely upon a general idea of the spicules and what the specimen preserved of the canal system.

The undoubted siliceous sponges from the Lower Silurian strata of northern Illinois are good examples of the replacement by calcite. In these the spicular mesh retains sufficient of its original structure to give us a fair idea of its details, while the canal systems, though often very complicated, are clearly defined and readily determinable. A number of the same species occur at Beloit, Wisconsin, but here the specimens are so poorly preserved that nothing whatever can be made out of their internal structure. I have also obtained several closely related species from Safford's Central Limestone, in Tennessee.* There, in common with the associated fossils, the specimens are siliceous, but the silica has undergone so much alteration that the internal characters are no longer distinguishable. The silica in these specimens has been much more changed than in the similarly preserved sponges from the *Astylospongia* beds of western Tennessee. Here, the entire sponge consists, usually, of a flinty mass in which the spicules and canals can often be traced out with comparative ease.

Sponges from which the siliceous skeleton has been dissolved, leaving perfect moulds, is another very common condition of preservation, especially among those of the Niagara group. In these specimens the siliceous spicular network has been entirely removed so that, instead of the solid spicule rays and nodes, we have only empty cavities that conform, however, most perfectly to the structures which formerly filled them. These moulds generally occur in a matrix of chert or flint which is eminently suitable for retaining the form of the sponge skeleton. In fact, I regard this method of preservation as being more favorable than any other met with in palæozoic rocks since, by pressing heated gutta-percha into the empty moulds, very perfect casts of the spicules are obtained. By this means I have been enabled to work out the structure of *Hindia*, *Aulocopium*, *Astylospongia*, *Palæomanon*, and other genera. In several instances the artificial casts of *Astylospongia* are so perfect, that they show clearly the branching of the spicule rays. Numerous examples are found in the Niagara strata of Tennessee, Kentucky and Indiana, while at Spring Valley, Minnesota, in beds of the same age, it appears that all the sponges are preserved in this condition. In the Burlington limestone of Illinois and Iowa, the Monactinellid sponge described in this report is often preserved in a similar manner.

The changes produced by fossilization in the structure of the calcareous sponges is generally more serious in its effects than

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* The beds from which these specimens were collected are regarded by Safford as forming part of his Central limestone. Recent investigations make me doubt that this is their true position. So far as the evidence at hand permits me to judge I should say that they constitute a distinct horizon between his Glade and Carters Creek limestones.

in the siliceous forms, though but little change may have occurred in the mineral substance. As a rule the calcareous spicules were minute and intimately united in the sponge fibre, so that it required but a slight amount of alteration to obliterate their form in the resulting fibro-crystalline mass of calcite. So far as observed, the spicules are never recognizable in the palæozoic calcareous sponges, excepting where they are isolated or project from the walls into the canal cavities. Some instances have also been met with in which the calcareous skeleton has been more or less completely replaced by silica. Several species of *Heterospongia*, a new genus with affinities to *Dystactospongia* and *Strotospongia*, and a general resemblance to Jurassic species of *Corynella*, present examples of this condition. These, as they occur at Cincinnati, Ohio, are always calcareous but at several localities in central Kentucky, where most of the fossils are also silicified, the same species are found having their skeletons strongly charged with siliceous material. The sponge fibre of such specimens is rough and preserves scarcely a trace of the spicular structure though in some the course of the canals and twisted walls can be distinguished with approximate certainty. Generally, however, this style of preservation is anything but favorable.

Geological distribution.

As may be expected, sponges make their appearance in the earliest fossiliferous rocks, and they are more or less numerously represented in all the succeeding great divisions of the geological scale to the present time. They attain the height of their development in the Jurassic and Cretaceous periods, in which rocks they form an important feature of the fauna. Their importance is less marked in Palæozoic and early Mesozoic groups, though they played a less subordinate part in Palæozoic times than is generally supposed. The fact is, they have been too much neglected by palæontologists, perhaps, because the specimens are rarely showy and in most cases appear as unsatisfactory, shapeless masses, little calculated to enthuse the collector. But the true naturalist should see beauty in all of Nature's handiwork, and I feel convinced, when once an interest is aroused in the study of these obscure fossil remains, their importance as factors of the palæozoic fauna will soon manifest itself. Thousands of specimens are now relegated to the "trash boxes" of collectors, nearly all of whom have something among their undetermined fossils, that would add to the list. Again, I suspect very much, that many of the so-called "Fucoids" really represent the remains of sponges, as has already been shown of *Dictyophyton* Hall, (*Hydnoceras* Conrad,) *Uphantænia* Vanuxem, and *Cyathophycus* Walcott.

THE TACONIC SYSTEM, according to Walcott*, already represents a sponge fauna comprising six genera and thirteen species. The figures of *Leptomitus zitteli* Walcott, (*loc. cit.*) suggest Monactinellid affinities, or, what is perhaps more likely, they represent basalia of some Hexactinellid sponge. The spicules of *Protospongia* have all the essential characters of the *Hexactinellidæ.* The peculiar genera, *Archæocyathus* Billings, and *Ethmophyllum*, Meek, are referred to the class with much doubt. In certain respects they suggest a line of evolution through *Beatricea* into the Stromatoporoids, while other peculiarities remind us of the Zoantharia Rugosa.

CAMBRIAN SYSTEM.†—Sponges are somewhat disproportionately distributed in Cambrian strata, but this is in part due to the unequal care exercised by collectors in searching for them. Thus the Trenton and Cincinnati groups have for many years been subjected to the most energetic searchings, and from these strata we have a correspondingly large number of sponges. None are as yet known from the Potsdam, but from the Calciferous group five species are described by Billings, belonging to the genera *Calathium* ?, *Ethmophyllum*, *Rhabdaria* and *Trichospongia*. Billings also describes from the uncertain Quebec group, five other species of *Calathium*, and the genus *Trachyum*, with two species.

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* C. D. Walcott, 2d Contr. to the Cambrian Faunas of N. A. Bull. U. S. Geol. Surv., No. 30.

† The term Cambrian as here used is equivalent to the Lower Silurian of Murchison and of the majority of American geologists; of the Ordovician of Lapworth, and of the Cambro-Silurian of the Canadian geologists. This arrangement seems to me to be the only just and practical settlement of the Taconic-Cambrian controversy which is receiving so much attention from geologists at present.

The Trenton period, including the rocks between the top of the Calciferous and the base of the Silurian, introduces a largely increased and much better preserved sponge fauna. The HEXACTINELLIDA are represented here by *Cyathophycus*, *Rauffella*, *Brachiospongia*, *Hyalostelia*, *Calathium* (*pars*), *Leptopoterion*, *Receptaculites*, *Lepidolites* and isolated spicules of a genus probably identical with *Astræospongia;* the LITHISTIDA by *Hindia*, *Astylospongia*(?), *Anthaspidella*, *Zittelella*, *Edriospongia*, *Streptosolen* and *Aulocopium*, the last by an undescribed species from the upper beds of the Trenton limestone in central Kentucky; and the CALCISPONGIÆ, probably, by *Strotospongia*, *Saccospongia*, *Dystactospongia*, *Cylindrocœlia* and *Camarocladia* in the Trenton limestones of Illinois and Kentucky; and by *Dystactospongia*, *Heterospongia*, *Streptospongia* and *Cylindrocœlia* in the Cincinnati rocks of Ohio and Kentucky. The systematic position of *Pattersonia* S. A. Miller, which seems identical with the lately proposed *Strobilospongia* of Beecher*; and of *Eospongia*, Billings, has not yet been determined.

SILURIAN SYSTEM.—Among Silurian deposits the Niagara group offers a number of localities where fossil sponges abound. They are most prolific in Western Tennessee, (Perry and Decatur counties) where the surface of the ground is sometimes thickly strewn with good specimens of *Astylospongia*, *Palæomanon*, *Astræospongia*, and *Hindia*, while the genera *Aulocopium*, *Climacospongia*, and at least one other genus, occur more rarely. None of the strata of this system below the Niagara have, so far as I am aware, furnished remains of sponges. It is, however, not at all unlikely that some at any rate of the numerous "fucoids" of the Clinton will prove eventually to be sponges and not plants. From above the Niagara, the Lower Helderberg contains sponges at certain localities. *Hindia sphæroidalis* Duncan (*Astylospongia inornata* Hall) is the principal form. This species seems to be identical with the common Niagara form of the genus.

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*Memoirs of the Peabody Museum of Yale University, vol. II, pt. I, p. 14, 1889. In this excellent contribution Mr' Beecher establishes the position of *Brachiospongia*. He shows the genus to belong to the Hexactinellidæ and proposes a new family, Brachiospongidæ, including, besides the type genus, also the new *Strobilospongia*.

DEVONIAN SYSTEM.—Except in one formation, sponges are very rare in the rocks of this age. The Hexactinellid genus *Dictyophyton* is common at several localities in the Chemung group of New York, while *Astræospongia* is occasionally found in the Hamilton group of Illinois and Iowa. The new genus *Syringophyllum*, from Hamilton strata of Northen Michigan, recalls the Silurian Anthaspidellidæ. A few specimens, not nearer determined, have been found among the silicified fossils at the Falls of the Ohio. The Devonian rocks of Europe are also very poor in sponge remains. Hinde describes *Lasiocladia*, a Monactinellid sponge from Belgium, while the Calcareous sponges are represented, according to Zittel, by a species of *Peronella*. The Lithistidæ are not represented unless the cast of a sponge from the Lower Devonian of Germany, named by Kayser *Lodanella mira*, belongs here.

CARBONIFEROUS SYSTEM.—European, and more especially the English authors, have paid considerable attention to the sponges of this system. Carter describes from the Carboniferous limestone of Scotland, the three Monactinellid genera *Pulvillus*, *Raphidistia* and *Reniera*, also *Holasterella*, belonging to the HEXACTINELLIDA; and Steinman furnishes the three genera *Sollacia*, *Amblysiphonella* and *Sebargasia*, which he regards as *Calcispongiæ*.

In American strata the MONACTINELLIDA are represented by *Belemnospongia* in the Burlington limestone of Illinois, and two species in the shales of the Keokuk group, one of which is provisionally referred to *Lasiocladia*. The new *Hystriospongia carbonaria*, from the Lower Coal Measures of Illinois, seems to be a Tetractinellid sponge in which the number of four-rayed spicules is exceedingly limited, while the general character of the skeleton of *Batospongia*, from the same horizon, strongly suggests the CALCISPONGIÆ. The HEXACTINELLIDA are represented by species of *Dictyophyton* in the Waverly group of Ohio, and the Keokuk group of Indiana and Illinois, as well as the fragments belonging to several related genera obtained from Lower Carboniferous localities in Illinois and Kentucky. *Uphantænia dawsoni* is described by Whitfield from the Keokuk group of Indiana.

Classification.

While the methods of investigation demanded by the advanced state of the study of natural science, make a natural classification possible, they add also very largely to the labors of the investigator. This is especially true of the student of palæozoic sponges, not only because the fossils of this class preserve so little of their structural details, but also because these early forms are ancestral types in which the characters, that in Mesozoic and more recent times have been separately developed into permanent structural characteristics, are as yet illy defined and generally blended together. The commingling of subsequently differentiated characters, even with the best preservation, imparts a degree of uncertainty to many of our determinations, but as we have in every instance sought to work out the minute structure as fully as the state of preservation of the fossils would admit, we hope the authorities on the subject will not take our views too much to task when they find it necessary to differ with us.

It is not deemed essential to refer to the classifications of D'Orbigny, Fromentel, and others, beyond stating that all have proven utterly inadequate because of their artificial character. This is clearly shown by the heterogeneous composition of the groups proposed in their systems. To Prof. Zittel belongs the honor of discovering the principle of a natural classification for fossil sponges. He accepts as the fundamental basis of his system the characters of the minute spicular bodies of which the sponge skeleton is composed. The validity of the system has already demonstrated itself by the excellent results of its application, since, where we formerly had a chaotic intermingling of distinct types, we now find the most harmonious arrangement.

According to the classification proposed by Prof. Zittel*, and adopted by Dr. Hinde†, and others, the Class Spongiæ is divided into the following Orders:

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* "Studien über fossile Spongien" I, II, III, Abh. d. Bay. Akad. d. Wiss. Bd. 13, 1877-78, and "Handbuch der Palæontologie."

† Catalogue Foss. Sponges, British Museum, 1883.

1. *Myxospongiæ* Haeckel. Sponges unprovided with a solid skeleton.

2. *Ceraospongiæ* Bronn. Skeleton consisting solely of horny fibres.

3. *Monactinellidæ* Zittel. Skeleton consisting entirely of uniaxial siliceous spicules, or of horny fibres enclosing an uniaxial siliceous core.

4. *Tetractinellidæ* Marshall. Skeleton consisting principally of four-rayed siliceous spicules, one usually elongated to form a shaft. Uniaxial and stellate spicules are also present.

5. *Lithistidæ* Schmidt. Skeleton composed of four-rayed or irregular siliceous spicules, which are often branchy and always closely interwoven so as to form a continuous mesh.

6. *Hexactinellidæ* Schmidt. Skeleton composed of isolated, or united and interwoven six-rayed siliceous spicules.

7. *Calcispongiæ* Blainville. Skeleton composed of calcareous spicules, either uniaxial, three or four-rayed.

Of these divisions five are known to be represented in the palæozoic rocks of America.

Zittel's system, as it is based mainly upon mesozoic and recent forms, fails, like Busk's and other classifications of the Bryozoa, to make full provisions for the palæozoic species, and many of them require some pressure to fit them into the accurately drawn divisions. However until something approaching a complete series of palæozoic sponges can be studied, it would be worse than useless to propose any serious changes from the arrangement adopted by Prof. Zittel in his "Handbuch der Palæontologie," excepting in such cases where the system has been improved upon by himself and other authorities on the subject.

Under this heading we desire to introduce a list of American palæozoic sponges, as nearly arranged according to the classification adopted as the present state of our knowledge would admit. As several changes and innovations are proposed, some remarks upon them are necessary to establish our claims. In order that the list may be as available for reference as possible, we prefer to give them here, rather than in the body of the catalogue.

The genera *Anthaspidella*, *Zittelella*, etc., described further on, have certain peculiarities which forbid classing them with any family of sponges known to me. A new family is therefore proposed for their reception, and defined as follows:

ANTHASPIDELLIDÆ, n. fam.

Sponges attached, simple or compound, saucer to funnel-shaped, often turbinate, more rarely sub-cylindrical, frondescent or sub-globose. Canal system often complicated, usually consisting of two sets, crossing each other at right angles. Skeleton composed of four-rayed spicules, consisting of a rod-like central portion and rapidly diverging bifurcations at each end, the form resulting being nearly }–{ shaped. The central portion is placed horizontally, with the bifurcations directed parallel with each other and at nearly right angles with the connecting bar. The bifurcations uniting to form radial columns and the connecting of the latter by the horizontal rods, results in forming what might be called a minutely tubular skeleton.

The family above characterized is proposed for the reception of a number of genera, mainly from Silurian strata, which in their various characters suggest affinities with very diverse types. Generally, the form of the sponge recalls the most typical Lithistidæ.

The species of *Zittelella*, for instance, in their macroscopic features resemble Jurassic *Cnemidiastrum* species so closely, that the microscope is required to prove their generic distinctness. On comparing the spicules of their internal skeletons, it becomes evident that they do not only belong to distinct genera, but that they really represent two very different families. On the other hand the arrangement of the spicules in columnar series, vividly recalls some of the Stromatoporoids. On plate VII we have illustrated for comparison the microscopic structure of two species of *Actinostroma*, Nicholson.* Recognizing the high authority of the men who advocate placing the Stromatoporoids with the Hydroida, it would be presumptuous on our part to deny

* In his several papers on the *Stromapotoroidea*, Dr. Nicholson has figured a number of species that would have served the purpose better.

their conclusion, yet we may be allowed to express our views to the effect, that the extraordinary resemblance between the columnar arrangement of the spicules in the Anthaspidellidæ and "radial pillars" of *Actinostroma*, etc., is due to homological affinities rather than the result of mere *accident*.

With two exceptions all the genera which it is proposed to include in the family are here described as new. *Anthaspidella*, *Zittelella*, *Streptosolen* and *Edriospongia* are from Cambrian strata, *Aulocopium* Oswald, and the very closely related *Climacospongia* Hinde, from Silurian, and *Syringophyllum* from Devonian beds. Besides these, several species now referred to *Calathium* Billings belong here. That genus contains, we think, at least two structurally distinct types. The first species described *C. formosum* Billings resembles *Craticularia* and may be, as has been suggested by Dr. Zittel, an early representative of the Euretidæ. *C. canadense* Billings or at any rate specimens from the Trenton limestone of Tennessee which we have identified with that species, have the characteristic spicular structure of the Anthaspidellidæ. The specimens are silicified and show a few spicules in a fairly satisfactory manner.

With the exception of *Climacospongia*, all the genera are characterized by more or less well marked canal systems. Two sets, radial and vertical, prevail in *Anthaspidella*, *Zittelella*, *Aulocopium* and *Edriospongia*. In *Streptosolen* the canals intertwine to such a degree, that it is difficult to separate the two sets, while in *Syringophyllum*, the radial system is represented by superficial channels only. In *Climacospongia*, the larger canals are wanting, but, instead, the spicules are larger, the horizontal bar longer, and, in consequence, the tubular mesh of more ample construction. This genus was described by Dr. Hinde* as a Monactinellid sponge. Specimens obtained from the typical locality clearly demonstrate that he misinterpreted the character of the interior skeleton, and that instead of vertically and horizontally arranged simple bi-acerate spicules, they are in reality four-rayed, and arranged in columnar series. These are formed by the intertwining of the vertically, or rather,

*Cat. of the Foss. Sponges in the Brit. Museum, p. 18, 1883.

radially directed end divisions of neighboring spicules. The spaces intervening between the "columns" are traversed by the horizontal bars imparting an irregular scalariform appearance to the spicular network in vertical sections. In transverse sections an irregular radial arrangement is obvious. In short the structure of the interior skeleton agrees very closely with that of *Aulocopium*, and, in all essential respects, with that of the remaining Anthaspidellids.

Figures 1 to 4 of the accompanying plate of cuts, illustrate the structure of *Climacospongia* as it appears in gutta-percha casts prepared by firmly pressing this pliable material into the empty moulds. The casts are not perfect representations of the original spicules, because the moulds of the "columns" are not entirely empty; but contain patches or particles of the peroxide of iron beside thin plates or threads of the siliceous matrix representing minute interstices between the spicule rays, which by their union form the columns.* Enough is shown, however, that we are not dealing with a Monactinellid sponge, but one that is, if not a true member of the Lithistida, at any rate very much like them.

In transverse sections the radial arrangement of the skeleton somewhat resembles the appearance of the spicular network of *Astylospongia* and *Palæomanon*, but, as has been shown by Martin and other observers, the spicules of those genera have from six to nine rays with minutely branched terminations. Their structure, therefore, conforms to that of the sponges included in the Lithistid family, Anomocladina. The spicule elements of the Anthaspidellidæ, however, are very different, being more like those which characterize the Megamorina and Tetracladina and, perhaps above all, are to be considered as altogether peculiar.

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*Fig. 1 shows a feature that is likely to prove misleading. I refer to the perforations at the ends of the horizontal portion of the spicules. Similar impressions or perforations were noticed in sections of the Trenton genera (pl. 5, fig. 3a). The appearance presented is sometimes rather suggestive of the "node perforations" of *Becksia* and other hexactinellid genera. These perforations are, however, too irregular to be of such a nature. Besides, the whole arrangement and character of the spicule elements of the new family as described above would in that case have to be abandoned, a course not to be entertained for a moment, since they are readily explained by assuming them to represent nothing further than mere interstices left between the diverging rays of the spicules. That the latter are fundamentally of the four-rayed type (in the same sense as are the skeleton elements of the Rhizomorina and Megamorina families) seems also scarcely within the range of doubt.

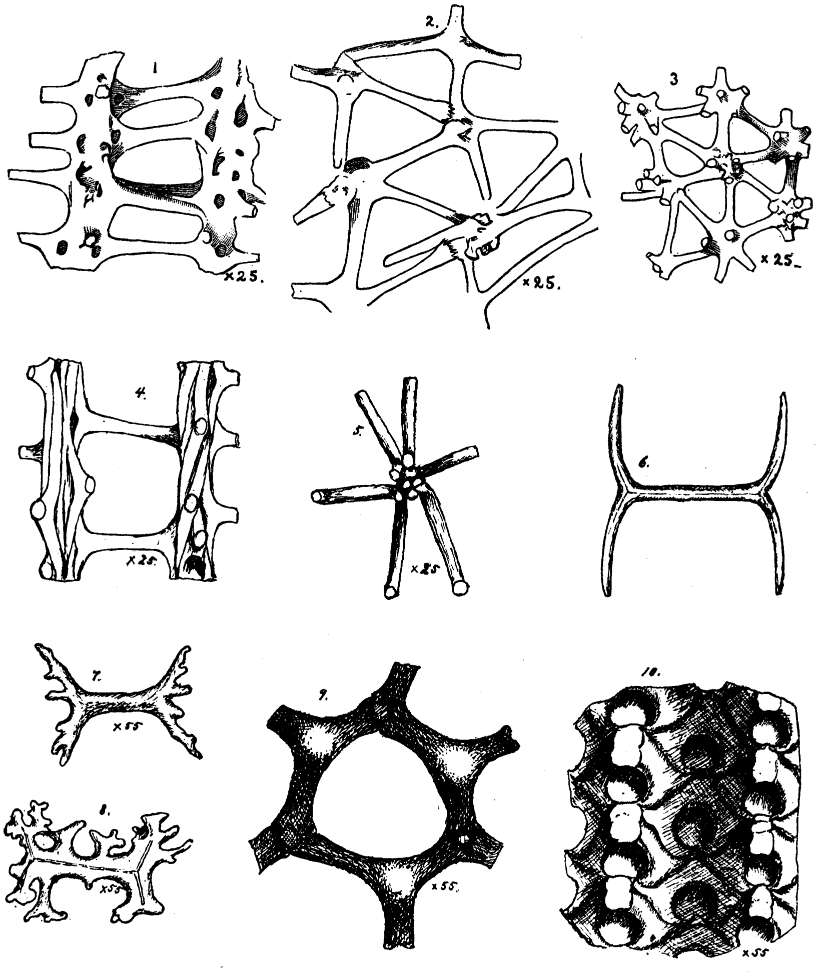

Fig. 1.—Two columns of spicules of *Climacospongia radiata* Hinde, magnified 25 times. Drawn from a gutta-percha cast taken from a natural mould. The specimen is from the Niagara group of Perry county, Tenn. The finer details of structure are not preserved.

Fig. 2.—End view of several columns of same, showing their arrangement and the connecting bars.

Fig. 3.—Spicules of *Astylospongia præmorsa* Roemer, mag. 25 times, as shown in gutta-percha casts. Niagara group, Perry county, Tenn.

Fig. 4.—Taken from another gutta-percha cast of *Climacospongia radiata* Hinde; x 25. In this cast the structure of the columns is shown in a very satisfactory manner. Position and locality same as for fig. 1.

Fig. 5.—End view of a single column of preceding; x 25.

Fig. 6.—Diagrammatic view of a spicule of *Climacospongia* and of the Anthaspidellidæ generally.

Fig. 7.—Spicule of *Aulocopium* sp., x 55. Silurian of Gotland.

Fig. 8.—Spicule of Rhizomorine sponge (*Seliscothon mantelli* Goldf., Cretaceous of Germany), showing axial canal and its division at each end; x 55. Introduced for comparison with the Anthaspidellidæ.

Fig. 9.—Small portion of surface of *Hindia sphæroidalis* Duncan, x 55, showing mouth of one of the radiating canals and three spicules. Niagara group, Spring Valley, Minn.

Fig. 10.—Portion of a gutta-percha cast taken from a vertically fractured example of the same; x 55.

So far as known, *Aulocopium* agrees in one character more nearly with the Tetracladine and Rhizomorine sponges than do the other genera here referred to the new family, the ends of its spicule rays, namely, being branched. In that respect, as well as in being considerably smaller, the spicules of *Aulocopium* differ from those of *Climacospongia*, the rays in the latter being, apparently always, simple and smooth. In none of the Trenton genera could the construction of the columns be determined, all the finer details having been destroyed during the process of calcification.

As regards the systematic position of the proposed family every character strongly favors a reference to the Lithistidæ. But when it comes to saying to which of the four already established families of the order the new division is the nearest related, we cannot speak with the same confidence. In the first place the comparatively regular form and grouping of the spicules suggests the Tetracladina, but the fact that these bodies are built upon a totally different plan, at once negatives the idea that any very intimate relationship exists here. In the Tetracladina the four arms of the spicules diverge from a center at angles of 120°. In the Anthaspidellidæ, on the other hand, the four rays are thrown off in pairs from the ends of what might be called a profoundly elongated node (the horizontal central bar).

The swollen central node and the general irregularity of the skeleton elements distinguish the Anomocladina.

In the Rhizomorina the branchy or nodulose and irregularly divided character of the spicules imparts a very distinctive appearance to them, yet when closely examined they are often found to be comparable with those of the Anthaspidellidæ. Thus, in *Jerieca,* Zittel, a central rod and two principal divisions at each end are frequently determinable. Lastly, in the Megamorina, the large spicules from which the family takes its name, occasionally also present points for comparison.

In the canal system and outer form of the spongarium the Anthaspidellidæ agree best with the Rhizomorine sponges. Since the skeleton elements also appear to resemble those of that family more than they do those of the Tetracladina, Megamorina and Anomocladina, it seems advisable to regard the new family as the initial one of the Lithistidæ, and as the best represented section of the order in the palæozoic rocks.

HINDIA Duncan.

Microspongia Miller and Dyer, Jour. Cin. Soc. Nat. Hist. vol. I, p. 37, 1878.

The genus *Hindia* was originally described in 1879, by Duncan as a calcareous sponge.* This view of the nature of the sponge was in my estimation successfully combated by both Hinde† and Rauff‡. These two observers, however, differ in the position assigned by them to the genus, the former being inclined to regard the genus as belonging to the Lithistid family Anomalocladina, while the latter refers it without question to the Tetracladina. My own investigations lead me to accept Dr. Rauff's conclusions as the most probable. In the main, my conclusions respecting the minute structure of the sponge agree very closely with those of both Rauff and Hinde, causing a detailed discussion of the genus to be almost superfluous. Still, as the points on which we differ will be brought out to better advantage, and, particularly since no account of this important fossil

* Ann. and Mag. Nat. Hist., ser. 5, vol. 4, p. 84.

† Catal. Foss. Sponges, Brit. Mus., p. 57, 1883; and Ann. Mag. Nat. Hist. for Jan. 1887.

‡ "Ueber die Gattung *Hindia* Duncan;" Sitzungsb. der Niederrh. Gesell. zu Bonn; Sitzung vom 10 Mar. 1886.

sponge has yet appeared in any American publication, I need not apologize for the following brief statement of facts relating to the genus and the several species known to me.

The type of *Hindia* is the *H. sphæroidalis* described by Duncan from Lower Helderberg specimens collected by Dr. G. J. Hinde, in New Brunswick. The same were previously described by Dr. Hinde as a tabulate coral and named *Sphærolites nicholsoni*. Of this paper nothing further than an abstract has ever been published†. The same species had been described and figured fifteen years before by Rœmer from the Niagara of western Tennessee, and identified by him with Goldfuss' *Calamopora fibrosa**. Again, it appears that Hall's description of his *Astylospongia inornata* (16th Reg't Rep't, 1863) is founded upon specimens of the same species from Lower Helderberg localities in New York.

We have here then a fossil which has received no less than four distinct specific names, and it is really a very difficult matter to decide which of them should be retained. Hinde and Rauff use *fibrosa*, but as Rœmer clearly regarded the Tennessee specimens as specifically identical with Golfuss' *Calamopora fibrosa*, I cannot see why he should be credited with a name of which he is not the author.

That he gave a sufficiently clear description of the Tennessee specimens cannot be denied, but that point has no bearing upon the real question, and it is of no consequence in the issue whether we decide his figures and description to be inadequate, or complete and sufficient for the identification of the species. The course almost universally adopted in cases of this kind (to my mind also the only rational and just one) is to give a new name to the species which upon subsequent investigation proves to have been erroneously identified with another. When they belong to the same genus the giving of a new name is, of course imperative. Why should the proceedings be any different when it happens, as in this case, that two species so confounded belong to different genera?

† Abstract of the Proc. Geol, Soc., No. 305, 1875.

* F. Roemer, "Silur. Fauna des Westl. Tenn. p. 20, pl. 2, fig. 2, 1860.

Hall's name *inornata* has a better claim to be retained, since not only did its author recognize the fossil as a sponge, but he also proposed a *new name* for it. The only objection to the adoption of Hall's name is that his description (no figures accompanying it) is not sufficient for the recognition of the species. The *form* is described well enough by the terms "globose or subglobose," but the statement that "from the point which appears to be the base, there are, in well preserved specimens, a few indistinct radiating lines," is misleading. Of the interior Hall says only that "a transverse section exhibits the characteristics of other species of the genus" (*i. e. Astylospongia*); now this statement not only does not aid in distinguishing the species, but is opposed to the facts, since the Helderberg specimens really belong to *Hindia*, and the interiors of that genus and of *Astylospongia* are in no respect alike.

Hinde's name, *Sphærolites nicholsoni*, would have been acceptable and appropriate enough had it been established, but as nothing more than only a short abstract of his paper on the fossil was published, neither the specific nor generic name is available.

Up to this time only Duncan's work on the species fulfilled all the requirements of proper publication, and, as he was the first to recognize the essential characters of the fossil, and to give us an adequate diagnosis of it, his name *Hindia sphæroidalis* is justly entitled to be retained for the species.

From the above we see that the species under consideration was first referred to *Calamopora*, then to *Astylospongia*, and subsequently formed the foundation of two new genera. Of the latter, *Sphærolites*, as has already been stated, has no claim to recognition, the author of the name having failed to publish his paper, and thus failed to establish his genus.

There is, however, another generic name that may dispute the title with *Hindia*. I refer to *Microspongia*, a genus proposed in 1878 by Miller and Dyer. Their description on page 37, vol. I, Jour. Cin. Soc. Nat. Hist., reads as follows:

"A free calcareous sponge, destitute of an epitheca. The texture is finely porous, without large canals or openings on the surface. Spicules (?) very minute and needle-shaped."

This description would scarcely lead anyone to suspect that the genus was founded upon a species which there is reason to believe, is congeneric with *Hindia sphæroidalis*. This belief is based upon the fact that only one globular sponge is known to me from the Cincinnati group, and that is unquestionably a *Hindia*. I have also seen specimens of this species which had been identified by Mr. Miller with his *Microspongia gregaria*.

If the originals of *Microspongia* are indeed the same as *Hindia* then we must decide whether the former name, which was proposed a year or more before the latter, is or is not entitled to recognition. If it is essential that a species or genus to be established must be described so that it can be recognized, then *Microspongia* cannot stand. There is nothing in the above quoted description, save the assertions that it is a calcareous sponge with (?) very minute needle shaped spicules, which would not apply equally well to *Astylospongia*, *Aulocopium* and one or two other palæozoic subspherical free sponges; and, taking for granted that the two names are really founded upon congeneric species, the description is false in the very points excepted, since *Hindia* is an undoubted siliceous Lithistid sponge with spicules of the Tetracladine type. Besides, the most important distinguishing features are not mentioned at all. Thus, while there are many reasons for abandoning the name *Microspongia* (always granting, of course, that the two names relate to one and the same genus) I see none of sufficient importance to justify its adoption at the expense of *Hindia*.

Hindia is represented in Cambrian and Silurian strata by at least three distinguishable varieties or species. The earliest, so far as known, is from near the base of the Trenton group (?Birdseye limestone) of northern Illinois. This is described in this volume by Dr. Everett and the author as *Hindia inæqualis* its main distinctive character being an unusual inequality in the size of the radial tubes. A nearly related smaller species (*H. parva* Ulrich) occurs at numerous localities in the upper or Galena division of the Trenton limestone, while a supposed variety of the same is occasionally found in the upper beds of the Cincinnati group at several localities in Illinois and Ohio. The third species is the *H. sphæroidalis*. This species, which must be regarded as the type of the genus, has a wide geographical distribution, and is common at many localities. It is known from the Silurian of Russia, Gotland, Germany, New Brunswick, New York, Indiana, Kentucky, western Tennessee and Minnesota. Of the specimens from American localities, those coming from the western states are in most cases silicified. In a large proportion of these again the skeleton has been more or less completely dissolved away, leaving only the empty moulds. In all of these, however, the superficial layers of spicules are preserved, but it is only in rare instances that the spicules were not distorted during the changes in mineral composition which nearly all fossil sponges have undergone during the process of fossilization.

In the calcareous examples of the genus, like those from the Cincinnati and Lower Helderberg groups, and part of those from Trenton and Niagara deposits, the minute details of structure are not clearly recognizable, but they serve very well in giving an idea of the general plan of construction. They show, for instance, that the skeleton is tubular and that the tubes, which in the same species (*H. inæqualis*) may vary in diameter from 0.2 to 0.7 mm., radiate in all directions from a central point. These tubes or canals enlarge very slightly toward the outer surface, and new canals are continually interpolated. In cross section they are obscurely hexagonal or subcircular, with their walls thin and perforated by six rows of minute round pores. Occasionally, also, sections of these calcareous examples may afford obscure evidences of the individual spicules, but they are never so conclusive as in the siliceous specimens and natural moulds.

The most perfect moulds seen by me come from the Niagara beds at Spring Valley in southern Minnesota. From these I have prepared a number of gutta-percha casts that for sharpness and beauty leave little to wish for.

Fig. 10, of the plate of cuts on page 224, represents an accurate camera lucida drawing of a small portion of one of these casts magnified 55 diameters. The specimen from which this cast was prepared is fractured vertically through the center and consequently exhibits the appearance of the skeleton on the inner side of the broken tubes. To understand this illustration it is necessary to study it in conjunction with fig. 9, which represents a small portion of the actual skeleton as it appears at the surface of one of the specimens from the same locality.

These figures, I believe, show in a reasonably clear manner that we are dealing with a Lithistid sponge of the Tetracladina type. The spicules are distinctly four-rayed, though the fourth ray is much less developed than the others and rarely is more than a mere stump.

In the typical Tetracladina the rays of the spicules diverge from a center at angles of about 120°. In *Hindia* the rays are similarly disposed, but the regular arrangement of the spicules into superimposed radial series so as to form tubes, appears not yet to have been noticed in any other genus of the family. It is a feature in which the genus may be said to simulate the Anthaspidellidæ.

The individual spicules have, as has been stated, four rays or arms extending from an inflated center. Three of the rays are nearly straight, of nearly equal length, with their extremities expanded mostly in a vertical direction. By their union a tripod-shaped body is formed from the upper surface of which the short fourth ray projects.

The connected structure of the skeleton is easily understood after we have once determined the true form of the individual spicules. In the first place the spicules form rather regular concentric layers, in which the individuals are arranged alternately so that any portion of each spicule is placed directly over or beneath the corresponding portion of the spicules of the third, fifth, seventh and ninth layers. The stumpy fourth ray is always directed toward the exterior, while the three tripodal rays extend toward the central nodes of three adjacent spicules of the layer immediately beneath. The upper portions of the expanded terminations in each case clasps about one-third of the fourth ray of the latter, while the lower portion extends downward in a recurving manner to the node or fourth ray of the spicule directly beneath it†. This process is carried on indefinitely, so that while each spicule is connected by three rays

† According to Dr. Rauff, the terminations are toothed and the junction of the spicules effected by the interlocking of the dentate portions. Although my material does not permit me to corroborate his observations on this point, I am not by any means ready to assert that he has misinterpreted the appearance of his specimens.

with three spicules of the layer next below it, it in like manner supports, on the upper side of its node and arms three rays of different spicules belonging to the series or layer next above.

The Minnesota specimens, which are in a better state of preservation than any others seen by me, exhibit at the surface great numbers of exceedingly minute, apparently acerate spicules, besides a small number of large Hexactinellids that are treated of in the next paragraph. The minute forms may represent a dermal layer, or so-called "flesh spicules;" or they may belong to an altogether different sponge, in which case their association with *Hindia sphæroidalis* would be purely accidental.

On plate II, fig. 4c represents a magnified view of a large Hexactinellid spicule, which is generally found with *Hindia sphæroidalis*, and not infrequently adheres to the surface of that sponge. At one time I supposed, because of their association, that they might belong to the surface layer of that species, but since the totally different character of the spicules of *Hindia* was ascertained, I have concluded that I was in error, and that the isolated spicules belong to a very different sponge. They resemble the regular six-rayed spicules of *Hyalostelia*, but as yet, I have not found with them any of the rod-like, stellate, nor anchor shaped spicules, which likewise occur (with the simple Hexactinellid forms) in *H. smithi* Y. & Y., the type of the genus. Provisionally, the spicules may be named *Hyalostelia solivaga*. In searching a slab of Lower Silurian limestone from near Cape Girardeau, Mo., for Bryozoa, I found smaller, but otherwise very similar spicules. Such spicules are also occasionally found associated with *H. parva* Ulrich, in the upper beds of the Trenton in Kentucky.

TABULAR LIST AND CLASSIFICATION OF AMERICAN PALÆOZOIC SPONGES.

The arrangement in families and orders is provisional, as future investigations will no doubt necessitate changes. Species marked with an asterisk to the left, are described or discussed in this volume.

	Taconic....	Cambrian....	Silurian.	Devonian....	Sub-carboniferous.....	Coal Meas..
Class SPONGIÆ.						
Order MONACTINELLIDA *Zittel.*						
LEPTOMITUS *Walcott*, 1886.	*	....	....	....	....	....
L. zitteli *Walcott*. (This genus is perhaps founded upon the basalia of some Hexactinellid sponge)	*	....	....	....	....	....
BELEMNOSPONGIA *Ulrich*, 1889	....	....	....	....	*	....
*B. fascicularis *Ulrich*	....	....	....	....	*	....
LASIOCLADIA *Hinde*, 1884	....	....	....	....	*	....
*L. hindei *Ulrich*	....	....	....	....	*	....
Order TETRACTINELLIDA *Marshall.*						
HYSTRIOSPONGIA *Ulrich*, 1880	....	....	....	....	....	*
*H. carbonaria *Ulrich*	....	....	....	....	....	*

	Taconic	Cambrian	Silurian	Devonian	Sub-carboniferous	Coal meas.
Order LITHISTIDA *O. Schmidt.*						
Family ANOMOCLADINA *Zittel.*						
ASTYLOSPONGIA *Roemer*, 1860		*	*			
A. christiana *Meek and Worthen.*			*			
A. imbricato-articulata *Roemer.*			*			
A. inciso-lobata *Roemer.*			*			
A.? parvula *Billings.*		*				
A.? perryi *Billings.*		*				
*A. præmorsa *Goldfuss.*			*			
A. præmorsa *var.* nux-moschata *Hall.*			*			
A. rœmeri *Hinde.*			*			
A. stellatim-sulcata *Roemer.*			*			
PALÆOMANON *Roemer*, 1860			*			
P. cratera *Roemer.*			*			
P. bursa *Hall.*			*			
EOSPONGIA *Billings*, 1861		*				
E. rœmeri *Billings.*		*				
E. varians *Billings*		*				
CYATHOSPONGIA *Hall*, 1882			*			
C. excrescens *Hall.*			*			
Family TETRACLADINA *Zittel.*						
HINDIA *Duncan*, 1879		*	*			
*H. inæqualis *Ulrich and Everett.*		*				
*H. parva *Ulrich*		*				
*H. sphæroidalis *Duncan.*			*			
Family ANTHASPIDELLIDÆ *Ulrich.*						
ANTHASPIDELLA *U. & E.*, 1889		*				
*A. florifera *U. & E.*		*				
*A. firma *U. & E.*		*				
*A. fenestrata *U. & E.*		*				
*A. grandis *U. & E.*		*				

	Taconic	Cambrian	Silurian	Devonian	Sub-carboniferous	Coal Meas.
*A.? magnifica *U. & E.*	....	*	....	....	....	....
*A. mamillata *U. & E.*	....	*	....	....	....	....
*A. parvistellata *U. & E*	....	*	....	....	....	....
*A. obliqua *U. & E.*	....	*	....	....	....	....
*A. scutula *U. & E.*	....	*	....	....	....	....
ZITTELELLA *U. & E.*, 1889	....	*	....	....	....	....
*Z. inosculata *U. & E.*	....	*	....	....	....	....
*Z. lobata *U. & E.*	....	*	....	....	....	....
*Z. trentonensis *Worthen, sp.*	....	*	....	....	....	....
*Z. typicalis *U. & E.*	....	*	....	....	....	....
*Z. typicalis *var.* pistilliformis *U. & E.*	....	*	....	....	....	....
*Z. typicalis *var.* subrotunda *U. & E*	....	*	....	....	....	....
*Z. typicalis *var.* turbinata *U. & E.*	....	*	....	....	....	....
EDRIOSPONGIA *U. & E.*, 1889	....	*	....	....	....	....
*E. basalis *U. & E*	....	*	....	....	....	....
STREPTOSOLEN *U. & E.*, 1889	....	*	....	....	....	....
*S. obconicus *U. & E.*	....	*	....	....	....	....
SYRINGOPHYLLUM *Ulrich*, 1889	....	....	....	*	....	....
* S. wortheni *Ulrich*	....	....	....	*	....	....
CLIMACOSPONGIA *Hinde*, 1883	....	....	*	....	....	....
* C. radialis *Hinde*	....	....	*	....	....	....
CALATHIUM *Billings*, 1865†	....	*	....	....	....	....
C. affine *Billings*	....	*	....	....	....	....
C. anstedi *Billings*	....	*	....	....	....	....
C. ? canadense *Billings*	....	*	....	....	....	....
C. fittoni *Billings*	....	*	....	....	....	....
C. formosum *Billings*	....	*	....	....	....	....
C. pannosum *Billings*	....	*	....	....	....	....
C. paradoxicum *Billings*	....	*	....	....	....	....
*C. ? ? infelix *U. & E*	....	*	....	....	....	....

† Only the doubtful species of this genus belong to this family. The typical species probably belong with the Hexactinellida.

	Taconic....	Cambrian...	Silurian	Devonian...	Sub-carboniferous....	Coal Meas...
Order HEXACTINELLIDA *O. Schmidt.*						
Suborder LYSSACINA *Zittel.*						
Family DICTYOSPONGIDÆ *Hall*‡.						
CLEODICTYA *Hall,* 1884	....	....	....	....	*	....
C. gloriosa *Hall*	....	....	....	....	*	....
C. ?mohri *Hall*	....	....	....	....	*	....
RAUFFELLA *Ulrich,* 1889	....	*	....	....	....	....
R. filosa *Ulrich*	....	*	....	....	....	....
B. palmipes *Ulrich*	....	*	....	....	....	....
CYATHOPHYCUS *Walcott,* 1879	....	*	....	....	....	....
C. reticulatum *Walcott*	....	*	....	....	....	....
C. subsphericum *Walcott*	....	*	....	....	....	....
C. quebecense *Dawson*	....	*	....	....	....	....
DICTYOPHYTON *Hall,* 1863	....	....	?*	*	*	....
D. abacus *Hall*	....	....	....	....	*	....
D. annulatum *Hall*	....	....	....	*	....	....
D. baculum *Hall*	....	....	....	*	....	....
D. cinctum *Hall*	....	....	....	*	....	....
D. conradi *Hall*	....	....	....	*	....	....
D. cylindricum *Whitfield*	....	....	....	....	*	....
D. fenestratum *Hall*	....	....	....	*	....	....
D. filitextile *Hall*	....	....	....	*	....	....
D. hamiltonense *Hall*	....	....	....	*	....	....
D. irregulare *Hall*	....	....	....	*	....	....
D. nodosum *Hall*	....	....	....	*	....	....
D. parallelum *Hall*	....	....	....	*	....	....
D. patulum *Hall*	....	....	....	*	....	....
D. prismaticum *Hall*	....	....	....	*	....	....
D. ? redfieldi *Hall*	....	....	....	....	*	....

‡ In the 35th Regt. Rept., Prof. Hall defines the family and a number of genera which he proposes to place in it. At this time I am not prepared to offer an opinion as to the validity of the proposed genera, nor of the numerous species which accompany them.

	Taconic	Cambrian	Silurian	Devonian	Sub-carboniferous	Coal Meas
D. rude *Hall*				*		
D. sacculus *Hall*				*		
D. telum *Hall*				*		
D. tenue *Hall*					*	
D. tuberosum *Conrad*				*		
ECTENODICTYA *Hall*, 1884					*	
E. burlingtonensis *Hall*					*	
E. eccentrica *Hall*					*	
E. expansa *Hall*					*	
E. implexa *Hall*					*	
LYRODICTYA *Hall*, 1884					*	
L. romingeri *Hall*					*	
PHRAGMODICTYA *Hall*, 1884					*	
P. catilliformis *Whitfield*					*	
P. lineata *Hall*					*	
P. patelliformis *Hall*					*	
PHYSOSPONGIA *Hall*, 1884					*	
P. alternata *Hall*					*	
P. colletti *Hall*					*	
P. dawsoni *Whitfield* sp					*	
THAMNODICTYA *Hall*, 1884					*	
T. newberryi *Hall*					*	
UPHANTÆNIA *Vanuxem*, 1843				*		
U. chemungensis *Vanuxem*				*		
Protospongia *Salter*, 1864	*	*				
P. fenestrata *Salter*	*					
P. ? minor *Matthew*	*					
P. ? minor *var.* distans *Matthew*	*					
P, tetranema *Dawson*		*				

	Taconic.....	Cambrian....	Silurian.....	Devonian....	Sub-carboniferous.....	Coal Meas...
FAMILY MONAKIDÆ *Marshall.*						
ASTRÆOSPONGIA *Roemer*, 1860,			*	*		
A. hamiltonensis *Meek and Worthen*				*		
A. meniscus *Roemer*			*			
FAMILY POLLAKIDÆ *Marshall.*						
HYALOSTELIA *Zittel*, 1878		*	*			*
* H. delicatula *Ulrich*						*
H. metissica *Dawson*		*				
* H. solivaga *Ulrich*		?*	*			
ASTROCONIA *Sollas*, 1881			*			
A. granti *Sollas*			*			
FAMILY BRACHIOSPONGIDÆ *Beecher.*						
BRACHIOSPONGIA *Marsh*, 1867		*				
A. digitata *Owen*, sp		*				
FAMILY RECEPTACULITIDÆ *Hinde.*						
RECEPTACULITES *DeFrance*		*	*	*		
Mr. S. A. Miller gives a list of 24 species of this genus in his "American Palæozoic Fossils" (edition of 1883). How many of these will prove to be valid species, and what forms, if any, are referable to *Ischadites* Murchison, and *Acanthoconia* Hinde, I am unable to say. I am, however, aware that Dr. Hinde has reviewed nearly all the American species in his valuable memoir on the *Receptaculitidæ*, but as this work is, unfortunately, not within my reach at present, I must be content with simply referring the reader to it.						

	Taconic....	Cambrian ...	Silurian	Devonian....	Sub-carboniferous.....	Coal Meas...
LEPIDOLITES *Ulrich*, 1879	....	*	....	....	....	....
L. dickhauti *Ulrich*	....	*	....	....	....	....
L. elongatus *Ulrich*	....	*	....	....	....	....
LEPTOPOTERION *Ulrich*, 1889	....	*	....	....	....	....
L. mammiferum *Ulrich*	....	*	....	....	....	....
Order CALCISPONGIÆ *Blaineville.*						
Family PHARETRONES *Zittel.*						
BATOSPONGIA *Ulrich*, 1889	....	....	....	....	....	*
* B. spicata *Ulrich*	....	....	....	....	....	*
CAMAROCLADIA *U. & E.*, 1889	....	*	....	....	....	....
* C. dichotoma, *U. & E.*	....	*	....	....	....	....
DYSTACTOSPONGIA *S. A. Miller*, 1882	....	*	....	....	....	....
* D. insolens *S. A. Miller*	....	*	....	....	....	....
D. minima *Ulrich*	....	*	....	....	....	....
* D. minor *U. & E.*	....	*	....	....	....	....
* D. rudis *U. & E.*	....	*	....	....	....	....
HETEROSPONGIA *Ulrich*, 1889	....	*	....	....	....	....
H. subramosa *Ulrich*	....	*	....	....	....	....
H. knotti *Ulrich*	....	*	....	....	....	....
H. aspera *Ulrich*	....	*	....	....	....	....
SACCOSPONGIA *Ulrich*, 1889	....	*	....	....	....	....
S. rudis *Ulrich*	....	*	....	....	....	....
S. danvillensis *Ulrich*	....	*	....	....	....	....
STROTOSPONGIA *U. & E.*, 1889	....	*	....	....	....	....
* S. maculosa *U. & E.*	....	*	....	....	....	....

	Taconic....	Cambrian....	Silurian....	Devonian....	Sub-carbon-iferous.....	Coal Meas...
STREPTOSPONGIA *Ulrich*, 1889		*				
S. labyrinthica *Ulrich*		*				
CYLINDROCŒLIA *Ulrich*, 1889		*				
C. endoceroidea *Ulrich*		*				
C. covingtonensis *Ulrich*		*				
C. minnesotensis *Ulrich*		*				
C. minor *Ulrich*		*				
INCERTÆ SEDIS.						
ARCHÆOCYATHUS *Billings*, 1862		*				
A. atlanticus *Billings*		*				
A. billingsi *Walcott*		*				
A? pavonoides *Matthew*		*				
AULOCOPINA *Billings*, 1875			*			
A. granti *Billings*			*			
EOCORYNE *Matthew*	*					
E. gemina *Matthew*	*					
ETHMOPHYLLUM *Meek*, 1868	*	*				
E. minganense *Billings*, sp		*				
E. profundum *Billings*, sp	*					
E. rarum *Ford*, sp	*					
E. rensselæricum *Ford*, sp	*					
E. whitneyi *Meek*	*					
PATTERSONIA *S. A. Miller*, 1882		*				
P. difficilis *S. A. Miller*		*				
RHABDARIA *Billings*, 1865		*				
R. fragilis *Billings*		*				
R. furcata *Billings*		*				

	Taconic....	Cambrian ...	Silurian....	Devonian....	Sub-carboniferous....	Coal Meas....
RIBEIRIA *Sharpe*, 1853	....	*	....	....	....	....
R.? calcifera *Billings*	....	*	....	....	....	....
R.? longiuscula *Billings*	....	*	....	....	....	....
TRACHYUM *Billings*, 1865	....	*	....	....	....	....
T. cyathiforme *Billings*	....	*	....	....	....	....
T. rugosum *Billings*	....	*	....	....	....	....
TRICHOSPONGIA *Billings*, 1865	....	*	....	....	....	....
T. sericea *Billings*	....	*	....	....	....	....

PART II.

PALÆONTOLOGY OF ILLINOIS.

SECTION IV.

Sponges of the Devonian and Carboniferous Systems.

By E. O. ULRICH.

SPONGES OF THE DEVONIAN AND CARBONIFEROUS SYSTEMS.

HYSTRIOSPONGIA CARBONARIA n. gen. et sp.

Pl. VI, Fig. 3.

The specimens which we propose to designate as above, are associated with species of the bryozoan genera *Fenestella*, *Polypora* and *Prismopora*, on a small slab of bituminous limestone. Their original form seems to have been sub-globular or ovoid, and less than 12 mm. in diameter, with the spicules arranged in a radiate manner from the base, sometimes parallel but at other times more irregular than those figured. The bulk of the sponge skeleton is composed of small biacerate spicules, about 1 m.m. in length, and 0.03 mm. in thickness. They are straight and taper each way to the pointed ends. Among them may be noticed a small number of similar spicules having one end trifid. A few four-rayed spicules of larger dimensions were also observed. In these the shaft is about 2 mm. long and 0.07 mm. thick, while the head rays are short and form the outline of an inverted three-sided pyramid. Acerate spicules 2 or 3 mm. long also occur among the smaller ones.

This sponge, as defined above, differs from *Tethyopsis* Zittel, and more especially from *Pachastrella* Schmidt, in the very limited number of the trifid spicules, and the small size of the acerate spicules. In *Ophiorhaphidites* Carter, the four-rayed spicules are also few, but the uniaxial forms are much longer and wavy.

In the residue left after freeing one of the specimens from the matrix by means of acid, I found, beside the spicules above described, a number of others, which could scarcely have belonged to this sponge. Some belong to the genus *Batospongia*, founded upon specimens from the same locality and supposed to be a calcareous sponge.

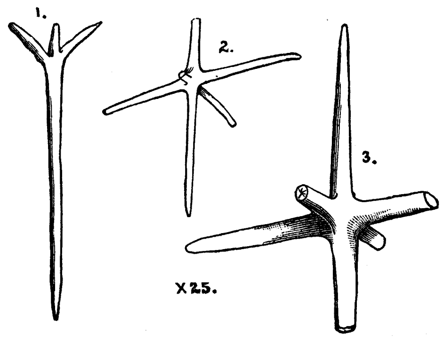

Fig. 1. A trifid spicule of Hystriospongia carbonaria, x 25.
Fig. 2. Small six-rayed spicule of Hyalostelia delicatula, x 25.
Fig. 3. One of medium size, x25.

Another kind, represented in the accompanying wood-cut, is of regular Hexactinellid form, and probably belonged to a delicate sponge of the type of *Hyalostelia* Zittel. This supposition is strengthened by the fact that they are associated with numerous fragments of linear spicules or rods, from 0.07 to 0.12 mm. thick. The longest fragment observed has a length of 5 mm. These spicules, being more slender and in all respects more delicate than those of the several species of that genus known, I propose to designate, provisionally, with the name *Hyalostelia delicatula.*

Position and locality: Near the base of the coal measures at Seville, Ill.

BATOSPONGIA SPICATA n. gen. et sp.

Pl. VI, Figs. 2-2a, 2b.

Sponge sub-hemispherical or sub-globose, consisting of small inosculating sub-cylindrical or flattened branches, 0.5 mm. to 1.5 mm. in diameter, which arise from a reticulated basal portion, and give the sponge a brushy appearance. In the perfect state the base is covered with a dense dermal layer, which, when separated, exhibits on its inner side a network of substellate or irregularly branched spicule fibre. The meshes of the reticulated basal portion of the sponge, (Pl. VI, fig. 2,) vary in size from

0.5 mm, to nearly 2 mm., and are arranged in an obscurely radiate manner. The branches are composed of small irregularly branched spicules (fibre?) which are compactly interwoven in the central region of the branches, but more loosely near the surface, where their form is approximately determinable. The branchlets of the spicules are slender and pointed, and project in all directions, so that the branches, when magnified, have a very spiny appearance. Extremely minute acerate spicules, scarcely 0.5 m.m. long, occur between the branched spicules, and in the matrix filling the space between the sponge branches.

So far as they can be made out the spicules of this species, agree, in a general way, with those belonging to the Lithistid family Rhizomorina. On the other hand the magnified branches are not unlike the spiny fibres of some of the Calcispongiæ (e. g. Peronella), and I do not consider it at all improbable, that better preserved examples will show that, instead of irregular four-rayed spicules with bifurcated rays, the spicules are really three-rayed. Their association with numerous minute acerate spicules, is more indicative of the Calcispongiæ than the Lithistida. Another circumstance suggesting an originally calcareous skeleton, was observed in freeing fragments of the sponge from the rock by treating with acid. One specimen proved to be siliceous, a fragment of another was so only in part, while the third (the specimen represented by fig. 2) proved, unfortunately, to be entirely calcareous, as it was nearly destroyed before its character was noticed. The residue of a part of the last specimen contained, beside numerous spicules of *Hystriospongia*, also several small partially silicified fragments of bryozoa.

None of the Calcareous or Lithistid genera of sponges with which I am acquainted, sufficiently resemble *Batospongia* to necessitate detailed comparisons.

Position and locality: The specimens are contained in a slab of bituminous limestone obtained from a layer near the base of the Coal measures, at Seville, Ill., where they are associated with *Hystriospongia carbonaria*, *Hyalostelia delicatula*, and numerous bryozoa.

BELEMNOSPONGIA nov. gen.

Sponges free (?), composed of elongate acerate spicules, which radiate upward and outward from a pointed base. The spicules are large, sub-equal and joined to each other by short processes, while they tend to arrange themselves into fascicles.

I am not acquainted with any genus of this order of the sponges from which *Belemnospongia* is not distinguished by the large size of the spicules, coupled with their tendency to become fasciculate, and in being united to each other by short lateral processes.

In a letter to the author, Dr. Hinde suggests that this genus might be compared with his *Climacospongia*. During the past summer (1886), I made extensive collections of the sponges from the Niagara group of Tennessee, and among them I found no difficulty in detecting several specimens of *C. radiata*. Upon careful examination I find that instead of belonging to the Monactinellida, as asserted by Dr. Hinde, *Climacospongia* is a real Lithistid, comparing favorably in the arrangement of the spicular mesh with the Anthaspidellidæ, to which family I propose to refer the genus.

BELEMNOSPONGIA FASCICULARIS n. sp.

Pl. III, fig. 2, 2a, 2b.

Sponges consisting of rather large acerate spicules, that radiate upward and outward to form a loose sub-hemispheric or discoid mass, with the base pointed, and the centre of the upper surface depressed. The spicules are straight, cylindrical, tapering gently to both extremities, 4 mm. to 8 mm. in length, 0.18 mm. in diameter, and united to each other by a small number of lateral processes, exhibiting at the same time, a more or less marked tendency to arrange themselves into bundles of three or more. At the surface of the best example the spicules are as a rule, smaller than those in the inner portions of the skeleton.

The specimens are preserved in chert nodules, and in all, save the one figured, the spicules have been dissolved and removed, leaving only the empty moulds. As is shown by a fracture, they are likewise gone in the interior of the mass of the illustrated example (Pl. III, fig. 2a). At the surface, however, the spicules themselves are preserved.

Position and locality: Rare in the cherty layers of the Burlington limestone, at Burlington, Iowa, and Montezuma, Pike county, Illinois.

From the shales of the Keokuk group I have collected specimens of two additional Monactinellid or possible Hexactinellid sponges, which, however, are generically distinct from *Belemnospongia fascicularis.* One is composed of extremely fine parallel fibres, or spicules, the length of which could not be determined. The other, as it is not uncommon, and easily recognized, I propose to name *Lasiocladia hindei.* A brief description is as follows:

Lasiocladia hindei, n. sp.

Sponge skeleton composed of elongate, slender, straight, acerate spicules, pointed at both ends, and closely arranged in sub-parallel series; their size is generally quite uniform, and varies little from 6 or 7 mm. in length, by 0.12 mm. in diameter.

The broken spicules of this species, are frequently seen scattered over the surface of slabs between the fronds of *Fenestella* and other bryozoa. A small slab, about two and one-half inches square and more than one-half inch thick, from Nauvoo, Illinois, is almost entirely composed of them. In this condition they present no recognizable arrangement, and only one specimen has been observed in which their normal arrangement is preserved. This is a very thin elongate fragment about 35 mm. long, by 7 or 8 mm. in width, which, under the ordinary pocket lens, presents the appearance of being composed of longitudinal fibres.

The type of the genus (*L. compressa* Hinde, from the Lower Devonian of Belgium) differs from *L. hindei,* in having stouter and shorter spicules. They are also differently arranged, in being directed upward and outward, instead of in longitudinal series.

Position and locality: In the shales of the Keokuk group at Nauvoo, Illinois; Keokuk, Iowa; and Kings Mt. tunnel, on the C. S. R, R., Lincoln county, Kentucky.

SYRINGOPHYLLUM nov. gen.

Sponges frondescent, with both sides deeply channeled. Channels parallel, increasing in number by interpolation. Vertical canals, arranged in linear series, pass through the expansion from side to side, opening into the bottom of the channels. Interspaces minutely tubular, the small canals originating in the central region of the expansion, and proceeding to each surface in a curved direction. Spicules and minute characters of skeleton apparently indistinguishable from *Anthaspidella*.

This genus, though clearly a member of the Anthaspidellidæ, differs greatly from the typical genera of the family, in the form of the sponge, arrangement of the canals, and the absence of distinct oscula.

Several sponges now referred to *Calathium* (e. g. *C. canadense* Billings and *C. infelix* U. & E.) are, perhaps, the nearest relatives known. From these *Syringophyllum* is distinguished by the frondescent form of the sponge.

SYRINGOPHYLLUM WORTHENI n. sp.

Pl. VII, figs. 4, 4a, 4b, 4c, 4d, 4e.

Sponge frondescent, consisting of an expansion several inches in diameter and 5 mm. thick. Both sides are deeply channeled in a like manner. The channels are parallel, radiately arranged from the base, five or six in 10 mm., increasing in number by interpolation.

The mouths of vertical canals, passing through the frond from side to side, are arranged in linear series, five to seven in 10 mm., along the bottom of the channels. The ridges between the rows of canals which, when worn, appear to be striated, are composed of a finely tubular spicular mesh, the spicules being arranged so as to form columnar series, extending from the centre of the expansion in a gently curved direction to each surface. In sections the spicular mesh is somewhat irregular, but the true Anthaspidellid type is often observable. (Pl. VII, fig. 4b.) The spicules in the spaces between the vertical canals are smaller and much more irregular, than those in the radiating ridges.

The specific name is given in honor of our distinguished chief, Prof. A. H. Worthen, who collected the unique example figured.

Position and locality: In shales of the Hamilton group, associated with numerous corals and bryozoa, at Thunder Bay Island, Michigan.

PART II.

PALÆONTOLOGY OF ILLINOIS.

SECTION V.

DESCRIPTIONS OF LOWER SILURIAN SPONGES,

BY E. O. ULRICH AND OLIVER EVERETT.

DESCRIPTIONS OF LOWER SILURIAN SPONGES.

The collection described on the following pages, comprises, without doubt, the most interesting and important addition to our knowledge of Palæozoic sponges ever made. The collection is so varied, and the preservation of the numerous specimens in general so favorable, that we have been able to make out with reasonable certainty, representatives of no less than three orders and ten genera. The Lithistida include by far the greatest number of the species, and the genera *Hindia*, *Anthaspidella*, *Zittelella*, *Edriospongia* and *Streptospongia*, as well as a section of *Calathium*. The minute structure of these genera, though mostly of a type not well recognized before, always contains the essential characters of the order. The remaining genera *Strotospongia*, *Dystactospongia* and *Camerocladia*, apparently belong to the Calcispongiæ.

All the specimens were collected by Dr. Everett at a quarry situated three miles northwest of his home in Dixon, Ill. They are found only in a shaly layer of Trenton limestone, from one to four or five inches thick, lying between heavy layers of sub-crystalline limestone, about twenty-five feet above the top of the St. Peter's sandstone. It is called the mud layer by the quarry men, but on examination it is found to be largely made up of organic remains. The shale is crowded with the stems of *Palæophycus* and *Buthotrephis*, while the enclosed thin slabs of limestone contain many of the characteristic fossils of the Trenton group. The sponges may be scattered all through the layer, or confined to particular spots in which they are especially abundant. Some of the slabs from these favored spots are literally covered with fragmentary and complete specimens.

The following list of characteristic Lower Trenton fossils have been recognized in the sponge layer:

Buthotrephis succulens *Hall.*
Palæophycus simplex *Hall.*
Monotrypa undulata *Nicholson.*
Homotrypa arbuscula *Ulrich.*
Poteriocrinus gracilis *Hall.*
Strophomena camerata *Conrad.*
Strophomena deltoidea *Conrad.*
Streptorhynchus filitextus *Hall.*
Orthis bellarugosa *Conrad.*
Orthis pervetus *Conrad.*
O. (Platystrophia) lynx *Eichwald* (small var.).
Raphistoma lenticulare *Emmons.*
Pleurotomaria rotuloides *Hall.*
Pleurotomaria subconica *Hall.*
Fusispira vittata *Hall.*
Fusispira subfusiformis? *Hall.*
Subulites elongatus *Conrad.*
Murchisonia gracilis *Hall.*
Maclurea bigsbyi *Hall.*
Ormoceras tenuifilum *Hall.*
Lituites undatus *Emmons.*
Cyrtoceras subannulatum *D'Orbigny.*
Illænus ovatus *Conrad.*

ANTHASPIDELLA nov. gen.

Sponges compound, saucer or funnel-shaped, supported by a short sub-cylindrical stem. Both surfaces of sponge wall with numerous inosculating radiating channels. As growth proceeds those of the upper surface are arched over by the spicular skeleton and form radial canals, which, by bending downward at their outer extremities, pass through the sponge wall, and open into the channels of the lower surface. These radiating canals are closely arranged in vertical series, each series being separated from the others by vertical sheets composed of spicular structure. The canals of each series communicate with each other sparingly, but more freely with those of the next series. Upper surface presenting a greater or less number of oscula, each provided with its individual system of radiating channels, which, however, gradually merge into the prevailing radiate arrangement. The depressed central portion of each osculum is occupied by the apertures of a limited number of rather large thin-walled vertical tubes, which traverse the sponge wall to half or less than half its thickness. Those in the central osculum extend throughout the stem.

Interior skeleton composed of }—{ shaped spicules, arranged in linear series so as to leave minute canals of triangular, quadrate, or polygonal form. Just below the centre of a vertical section of the sponge wall, these capillary canals run nearly parallel with the lower margin. From this region they proceed in a gradually diverging and curved direction to each surface.*

Both surfaces sometimes covered with a dense dermal layer.

Types, *A. florifera* and *A. mammulata.*

The minute internal structure of the species referred to this genus and described on the following pages, is practically identical in all. This we believe to be largely due to the destruction of the finer details of structure, consequent to the replacement of the original siliceous material by crystalline calcite. The same may be said of the spicular mesh of *Zittelella*, *Edriospongia* and *Streptosolen* when compared with that of *Anthaspidella.* We were, therefore, obliged to depend entirely upon external features and variations in the systems in distinguishing the genera and the species referred to each. As these characters are often unreliable among the sponges, we will not be surprised if future investigations prove that we have made more species and, perhaps, even genera than was necessary. The field being comparatively new and exceedingly difficult, we *expect* our work to prove faulty in some respects; yet, whatever errors we may have fallen into, we will find consolation in the conviction that we have done the best we could under the circumstances.†

* For further information respecting the interior see discussion on the Anthaspidellidæ, on pages 221 to 226.

† Since the above was written Mr. Ulrich visited Dixon and succeeded in collecting a considerable number of these sponges. Their study proved very gratifying to us, since we found no difficulty whatever in placing every specimen save a few, belonging to as yet undescribed species.

ANTHASPIDELLA MAMMULATA U. & E.

Pl. I, Fig. 1, 1a, 1b, 1c, 1d.

Sponge having the shape of a widely expanded funnel, with the margin abruptly rounded. Upper surface deeply concave. Oscula numerous, occurring at intervals varying from 5 to 20 mm. They occupy the summits of more or less elevated monticules, and when the compact dermal layer is preserved, their abruptly depressed apertures, having a diameter of 2.5 mm. or less, are rounded and sharply margined. When the outer layer is wanting, they are surrounded by from six to ten radiating canals. As usual, the oscula are most numerous in the central portion. The furrows of the radiating canals inosculate rather freely. Under surface comparatively even, with the sides nearly straight or faintly convex, and marked by radiating furrows, of which seven to nine occur in 0.5 of an inch. The margins of these furrows may be entire, more often serrated, and, less commonly, connected with those adjoining by transverse canals.

The canal system, as brought out by sections, consists principally of the radiating canals, which, penetrating the sponge wall in a curved direction and at right angles to the minute canals formed by the spicular mesh, are arranged in vertically superimposed series. Those of adjoining series are connected with each other at more or less frequent intervals by short canals, arranged in such a manner that they might be mistaken for another series of canals running parallel with the capillary canals. This, however, is not their true nature, as the section clearly shows that each of the supposed canals is formed by a series of closely approximated connecting canals. (*See* Pl. I. fig. 1b.)

Diameter of an ordinary sized example, 100 mm.; entire height about 38 mm.; depth of cup, 25 mm.; thickness of wall from 7 to 10 mm.

The greater concavity or depth of the upper surface and general form of the sponge, separate *A. mammulata* from such species as *A. florifera*, *A. scutula* and *A. parvistellata*, while the pustulate form of the oscula furnishes the most characteristic feature of the species.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Ill.

Anthaspidella florifera U. & E.

Pl. I, Fig. 2, and Pl. IV, Fig. 2.

Sponge saucer-shaped, usually very shallow and abruptly expanded above the short stem. Margin sharp or narrowly rounded. Under surface comparatively even, sometimes with a few irregular shallow radiating and concentric depressions. The channels on the under surface are united at frequent but irregular intervals by cross furrows. Their width usually equals about one-half that of the intervening wall-substance. Upper surface gently concave, with a central osculum, surrounding which, at a radius of from 18 to 25 mm., is an irregular circle of similar, but slightly smaller oscula. In very large specimens a second series is developed at about the same distance from the first circle. In the first circle the oscula number from six to eight and are separated from each other by 12 mm. or more. The center of each is slightly, but rather abruptly depressed, and occupied by the apertures of a group of six or more vertical, very thin-walled canals, about 0.7 mm. in diameter.

Radiating in all directions from the oscula, the surface presents a series of canals which sometimes anastomose rather freely with each other, but, more commonly, are connected at more or less remote intervals by transverse furrows or canals. The width of these channels sometimes nearly equals that of the intervening sponge tissue, but generally is not more than half as wide. In the central portion of the sponge seven or eight of the radiating canals may be counted in the space of 10 mm., while near the outer margin five or six suffice to fill the same space. A section, dividing the sponge vertically through the centre, shows that the tubes occupying the central osculum are continuous from the base of the stem to the upper surface, while those occupying the other oscula do not penetrate the walls of the sponge more than half its thickness. On each side of the central tubes the section shows a number of radiating canals at distances apart of 1.2 mm. or more, which run parallel with the upper surface, and therefore curve downwards at their outer ends, and open into the radiating furrows observed on the lower surface. They are occasionally united with each other by vertical, but, more frequently, by transverse canals. A distinct series of capillary canals is formed by the regular arrangement of the spicular tissue. These proceed to each surface in gradually diverging curved directions from a line parallel with, and much nearer the lower than the upper surface.

Entire height of an ordinary specimen 37 mm.; height of stem 12 mm.; diameter of cup 88 mm.; depth of cup 10 mm.; thickness of wall about 12 mm.

More specimens of this beautiful species were obtained than of any of the others here described. They are easily recognized by the comparatively few oscula, and regularity of the radiating canals around the large central one, which is also more defined than in any of the other species.

Position and locality: Twenty-five feet above the base of the Trenton limestone near Dixon, Ill.

ANTHASPIDELLA PARVISTELLATA U. & E.

Pl. I, fig. 3.

Sponge patelliform, very shallow and abruptly expanded above the short stem. Walls thin, with a few irregular concentric and radiating depressions on the lower side. Margin subacute. Upper surface gently concave in the central portion, and slightly convex towards the margin. Oscula comparatively small, numerous, numbering at least seventy. Nearly all of these occur in the inner two-thirds of the diameter, they being but sparingly or not at all developed in the outer third. Where they are most numerous, more than twenty may be counted in one inch square. Each is surrounded by from five to nine radiating furrows, giving them a decidedly stellate appearance. Between and beyond the oscula the surface is radiately furrowed. The furrows are usually half the width of the intervening sponge substance. They bend down toward the lower surface more abruptly than usual. It is due to the last fact that when but slightly worn, the sponge presents the appearance of being traversed by vertical canals, the rounded apertures of which are closely arranged in radiating series (see Pl. I, fig. 3.) The canals on the lower side of the sponge wall are usually irregularly serrated at their sides, or they may inosculate with each other without losing their distinctly radial character. From six to eight occur in a space 10 mm. wide.

The internal structure conforms with that given for the genus.

Diameter of a specimen 88 mm.; thickness of wall from 5 to 8 mm.; height of expanded portion of sponge 13 mm.; height of stem unknown, apparently not more than 15 mm.

The small size and great number of the oscula characterize this species, and serve to distinguish it from *A. scutula* and *A. florifera*, both of which have a somewhat similar form.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Illinois.

ANTHASPIDELLA SCUTULA U. & E.

Pl. III, fig. 1, 1a.

Sponge large, saucer shaped, rather shallow, and abruptly expanded above the short sub-cylindrical stem. Margin sharp. Under surface very uneven, with rough, irregular prominences and depressions, which are often arranged in a somewhat concentric manner. On account of the irregularity of the under surface, the radial character of the furrows is less distinct than usual. Upper surface concave throughout, excepting just at the inside of the outer margin where it is convex. Oscula of moderate size, numerous, from 5 to 12 mm. apart, and surrounded by from eight to fifteen radial canals. On account of the great number of the oscula, the radiating furrows or canals inosculate freely with each other. This is especially the case over the central region of the surface; nearer the margin their arrangement in series radiating from the centre of the sponge becomes more apparent.

Canal system and interior skeleton like that of *A. mammulata.*

Diameter of a large specimen 168 mm.; entire height about 50 mm.; hight of expanded portion 37 mm.; depth of cup 28 mm.; thickness of wall from 10 to 18 mm.

This species is readily distinguished from all others here described, by its extremely roughened under surface.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Illinois.

ANTHASPIDELLA GRANDIS U. & E.

Pl. II, fig. 2, 2a.

Sponge very large, consisting of a discoidal expansion, the upper surface of which is flat, or very slightly concave. Outer margin sub-acute or rounded. The entire upper surface is marked by frequently connected radiating furrows, the regularity of which is more or less disturbed at very unequal intervals by the development of an osculum. Oscula rather inconspicuous and unequal, from 12 to 50 mm. apart. Lower surface somewhat roughened, and traversed by frequently connected or only serrated radiating furrows. Over limited portions of the surface they are sometimes almost labyrinthically intertwined, when their radial character may be entirely obliterated or, at least, much obscured.

No complete specimen of this species has as yet been found, but judging from the fragments before us the sponge attained a diameter of no less than 500 mm., while its entire height does not appear to have been more than perhaps two or three inches. The fragments show further, that, though the sponge was extremely expanded, the thickness of the wall never exceeded 20 mm., while it is usually not more than 12 or 15 mm.

The shape and large size of the sponge, as well as the irregular disposition of the oscula, serve readily to distinguish this species from any of the associated forms.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Illinois.

ANTHASPIDELLA FIRMA U. & E.

Pl. II, fig. 3, 3a.

Of this sponge the specimen figured is the only one observed.* Its shape is obliquely depressed-obconical, the cup shallow, and its margin acute, the stem strong, and apparently very short. The under surface shows two faint constrictions, besides several nodular protuberances. The furrows are strong, four to six in 10 mm., and more or less irregularly interrupted, being especially so upon the shorter side. The comparatively large, oval or circular mouths of the radiating channels, are visible in the bottom of the furrows. About seven occur in 10 mm.

The oscula of the upper surface are deeply impressed, irregularly stellate, of moderate size, and the twenty-seven that can be determined are confined to the inner two-thirds of the cup; the canals which radiate from them, are strong and usually proceed but a short distance when their diameter is diminished, and their identity lost in the confused canal-network prevailing over the central portion of the surface. It is only toward the margin of the cup that the channels assume a common radiate arrangement; yet, even here, they inosculate rather freely.

The canal system, as shown by cutting the specimen vertically through the centre, proves to be in all important particulars considerably like that of *A. florifera*. The canals, however, are larger and the radiating canals less curved downward at their outer ends, appearing also, much less continuous in the section.

Height of sponge about 50 mm.; greatest diameter of cup, 92 mm.; depth of same 13 mm.; diameter of stem, where broken about 25 mm.

The canals of this species are larger and more widely separated than in any other of the species here described, and as the type specimen differs more or less obviously in other respects from them, it is difficult to decide to which *A. firma* is the most closely related. These peculiarities, however, are only of specific importance, and the species is clearly congeneric with *A. mammulata*.

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* Another specimen of this species was collected lately by Mr. Ulrich.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Illinois.

ANTHASPIDELLA FENESTRATA U. & E.

Pl. II, fig. 1.

Sponge infundibuliform or campanulate, with the cup rather deep. Above the comparatively large and irregularly sub-cylindrical stem, the sides diverge with a gentle outward curve to the acutely rounded and slightly oblique margin of the cup. Wall about 10 mm. in thickness. Outer or under surface, where unworn, with distinct vertical furrows, seven or eight in 10 mm., into which the radiating canals open. On the stem the furrows are irregularly disposed and united at frequent intervals by short transverse channels.

Upper surface deeply concave, with a large central osculum, from which ten or twelve strong channels radiate. Over fifty, similar, but smaller oscula are unequally distributed over the remaining surface of the cup; each is surrounded by from five to ten radiating channels, which proceed but a short distance before they merge into the principal furrows; these, despite the numerous interruptions, always maintain a general outward direction from the centre of the cup.

Entire height of a good example about 90 mm.; greatest diameter at margin of cup 80 mm.; diameter of stem 20 mm. or a little less; depth of cup about 23 mm.

In external form this species somewhat resembles both *A. obliqua* and *A. magnifica.* From the first of these it differs in its larger size, less expanded cup, and much more numerous oscula, while the radiating furrows communicate by means of transverse channels rather than by anastomosis. From *A. magnifica* it is distinguished by its smaller size, furrowed outer surface, and generally larger canals and oscula.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Illinois.

ANTHASPIDELLA OBLIQUA U. & E.

Pl. IV, fig. 1, 1a.

Sponge funnel-shaped, gradually expanding above the subcylindrical stem. Margin of cup narrowly rounded and somewhat oblique. Upper surface depressed, and sloping gradually towards the centre, where the best specimen shows a group of three oscula, each surrounded by from twelve to sixteen radiating canals, which inosculate with each other and bifurcate rather freely toward the outer margin of the sponge. The sponge tissue between the canals is thinner than usual, being generally of less width than the diameter of the canals. Outer and under surface apparently smooth or even, with the sides concave and traversed by vertical furrows in which the closely arranged apertures of the radiating canals, which have penetrated the walls of the sponge from the upper surface, are plainly to be seen. On portions of the stem the canals are very irregular.

Only two imperfect specimens of this species have been observed but as they show decided peculiarities, it has been thought desirable to describe them. Judging from the form of the specimens, the affinities of the species lie with *A. fenestrata*, from which, however, it is easily distinguished by the smaller size, more expanded cup, and different arrangement of the canals and oscula on the upper surface.

Diameter of cup of best specimen 40 mm.; entire height 53 mm.; diameter of stem about 15 mm.; depth of cup 9 mm.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Illinois.

ANTHASPIDELLA? MAGNIFICA U. & E.

Pl. VIII, fig. 2, 2a, 2b, 2c.

Of this fine species the collection affords but a single example, which is figured, partly in outline, on plate VIII. By sawing it vertically through the centre we were enabled to free the deep cup of the enclosed rock, and to trace out the canal systems which are well shown in the wall sections. The entire specimen is funnel or goblet-shaped, the stem strong, sub-cylindrical, irregularly expanded below, and marked by the more or less confluent and irregularly distributed apertures of small canals, rarely more than 0.5 mm. in diameter. Above the stem on the outer side of the cup, the same irregularity pertains to the distribution of the canal openings and continues to within one inch of the cup margin, where they arrange themselves into vertical series. The outer surface of the cup, especially just above the stem, is faintly mammulated, the broad eminences low and with an obscure vertical arrangement. The cup is deep, and on its sloping sides presents a large number of small slightly raised stellate oscula, 1.5 to 2 mm. in diameter; ten or more may be counted in a space one inch square. Below the dense cortical substance which covers the intermediate spaces in the perfect state, the canal furrows inosculate freely, but a tendency to follow lines radiating from the centre of the cup to the margin is always maintained. A vertical section of the specimen shows that the central portion of the stem is traversed by vertical canals opening into the base of the cup. The same series of canals continues on into the walls of the cup. Here they originate along an imaginary line dividing the sponge wall into two layers, an inner one that nearly maintains its thickness throughout the cup-wall, and a thinner outer layer that gradually diminishes in thickness from the base of the stem to the margin where it is wanting. The canals in question pass through the inner layer in a curved direction and open at right angles with the surface into the cup cavity. The outer layer is traversed in an opposite direction by similar, but shorter and more numerous canals. A third series is shown in the upper portion of the section figured (Pl. VIII, fig. 2c). These proceed apparently from the oscula, and passing through the inner layer in an opposite direction from those already described, terminate, at the line marking the beginning of the outer layer. The spicular structure does not differ, so far as observed, from that of *A. florifera* and the other species.

Height of specimen 150 mm.; diameter of stem 35 mm.; approximate diameter at cup margin 140 mm.; depth of cup 70 mm.; average thickness of cup wall 17 mm.; thickness of inner layer about 10 mm.

This species differs considerably in its canal system from *A. florifera* and *A. mammulata*. In those species the vertical canals are almost entirely restricted to the oscula, while the radiating canals are much the more numerously met with in sections. The opposite is the case with *A. magnifica*, since the radiating canals are but rarely seen in the sections, while the vertical ones are numerous. None of the other species seem to have been provided with an outer layer like that described above, as in all, (so far as their preservation will admit of determining this point) the radiating canals open on the outer surface into the vertical grooves. Except at or near the margin of the cup, this is not the case in *A. magnifica*, since in this species they do not pass through the outer layer. The functions of the latter was probably the same as that of the ordinary dermal layer of the sponges. The differences may indicate another genus of this peculiar family of sponges, but till they are proven to be of generic importance by finding them in other forms, we prefer to place the species, at least provisionally, with *Anthaspidella*.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Illinois.

Zittelella nov. gen.

Sponges simple, pedunculate and attached, varying in shape from depressed obconical, turbinate or sub-spherical, to sub-cylindrical; rarely lobate. Upper surface with a shallow central depression into which a variable number of thin-walled vertical tubes, extending through to the base of the sponge, open. Canal system consisting principally of a series of radiating canals, which may inosculate freely with each other, or only to a limited degree in their passage through the walls of the sponge from the outer surface to the vertical central tubes. The radiating canals are closely arranged in vertical series, separated by spicular tissue from one to three times as wide as the canals. This arrangement of the canals gives the sponge the appearance of being divided by vertical fissures. Interior skeleton as in *Anthaspidella*, excepting that the capillary canals run parallel with the sides of the sponge wall, and open only at the upper surface.

Under surface sometimes covered with a dense dermal layer. Type *Z. typicalis*.*

ZITTELELLA TYPICALIS U. & E.

Pl. V, fig. 5, 5a.

Sponge vase or funnel-shaped, with a comparatively long sub-cylindrical stem. Upper surface slightly depressed, and marked by somewhat regular radiating canals uniting more or less freely with each other by means of lateral divisions, or by inosculation. The width of the channels is about 0.6 mm., while from eight to ten occur in 10 mm. The depressed centre of the cup surface exhibits the apertures of nearly fifty vertical tubes, each about 0.8 mm. in diameter, having very thin walls. The sides of the sponge spread rapidly above the stem, and usually exhibit a number of shallow vertical depressions, as well as the vertical channels. About five of the latter occur in a space 10 mm. wide. The vertically arranged mouths of the radiating canals are shown in the place of the channels when the specimens are worn; six or seven in a series 10 mm. long. On the stem the channels are short, numerous, and irregularly arranged. From the fact that the radiating channels of the upper surface are more numerous than those on the sides, it appears that many of the radiating canals are blind, (*i. e.* terminate before reaching the outer surface) or, that all of the radiating channels are not converted into internal canals.

The best specimen (a small one) is 44 mm. in height, and 60 mm. in diameter; the stem about 18 mm. long, and 20 mm. in diameter.

The above describes the typical form of the species, but the collection contains a number of sponges from the same locality, which, while they do not appear to be distinguishable by specific

* The absence of radiate oscula distinguishes this genus from *Anthaspidella*. *Aulocopium* and *Climacospongia*, have different canal systems.

characters, can, nevertheless, be recognized by peculiarities of form and other features of minor importance. For these we propose the varietal names *pistilliformis*, *turbinata* and *subrotunda*.

var. PISTILLIFORMIS U. & E.

Pl. V, fig. 4.

This variety is distinguished from the typical form of the species by having a more distinct stem, the radiating channels less regular, and oftener united by inosculation, the vertical cloacal tubes somewhat larger and much less numerous, and the upper surface convex instead of flat. The three specimens referred to the variety are also smaller, the largest being only 36 mm. high, while the greatest diameter is 35 mm.

var. TURBINATA U. & E.

Pl. V, Fig. 3, 3a, 3b, 3c, 7, 7a.

The turbinate form of the sponge is the distinguishing character of this variety. In all other respects a close resemblance to the typical form prevails. Six specimens are referred to the variety. The two examples, illustrated on plate V, are of medium size.

var. SUBROTUNDA U. & E.

Pl. V, Fig. 2, 2a.

This form is related to var. *turbinata*, but differs from it, and to a greater degree from var. *pistilliformis*, and the typical form of the species, in the subglobose body of the sponge. The central or cloacal depression is deeper than usual, and it does not appear that the sponge was prolonged below into a stem.

We have seen only two specimens which could be referred to this variety, and both are much worn and imperfect. In their present condition they present very little resemblance to *Z. typicalis*, but fearing the differences might in part be due to the poor state of preservation, and as the var. *turbinata* is an intermediate form, we preferred to class them as above.

This species and varieties is, perhaps, more closely related to *Z. trentonensis* Worthen sp.*, than to any other of the species found at Dixon, Ill. They are easily distinguished by the depressed obconical form of that species, and the very short or rudimentary stem. The channels are also separated by wider interspaces than in the present species.

Position and locality: Twenty,five feet above the base of the Trenton limestone, near Dixon, Ill.

ZITTELELLA LOBATA U. & E.

Pl. IV, Figs. 3, 3a, 3b, 3c.

Sponge of an irregular obconical form, with the upper surface flattened, the sides or lower surface deeply sulcate or irregularly lobate, and abruptly expanded above the stem. The radiating channels of the upper surface are moderately regular, with an average of seven in 10 mm. The cloacal tubes are 1 mm. in diameter, and ten or more in number. The outer portion of the upper surface also exhibits a number of shallow impressions, arranged in an irregularly radiate manner around the centre. On account of the irregular lobate character of the under surface the channels here are also irregular. In the perfect state they are covered by a dermal layer, the characters of which have not been ascertained.

A large specimen has a height above the stem of 30 mm.; the greatest diameter of the upper surface is 90 mm. The stem is compressed and of unknown length. The longest and shortest diameters are, respectively, 22 mm., and 13 mm.

This well marked species is readily distinguished from all associated forms by the irregularly lobate character of the under surface.

Position and locality: Twenty-five feet above the base of the Trenton limestone near Dixon, Ill.

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* *Cnemidium? trentonensis*, Worthen, Ill. Geol. Sur, Rep'ts, Vol. VI, p. 491. 1875.

Zittelella inosculata U. & E.

Pl. V, Figs. 6-6a.

Sponge pestle-shaped, the stem large, subcylindrical, the upper portion expanded, with the margin narrowly rounded into the convex upper surface. The vertical channels on the sides of the sponges are very irregular and frequently united. The interspaces vary in width from one to three mm., and the number of channels in a space 10 mm. wide, from four to seven, while the average number is about five. The central portion of the upper surface is abruptly depressed, the depression stellate, and exhibiting at the bottom the mouths of from four to eight cloacal tubes. The radiating furrows are wavy, bifurcate and inosculate freely with each other, and from 0.5 mm. to 0.8 mm. in width. The interspaces which are narrow wedge-shaped in the region about the cloacal depression, vary in width from 0.2 mm. to 2 mm., being widest at the margin.

Height of a medium sized specimen, 33 mm.; diameter of stem varying from 14 to 18 mm.; height of same 21 mm.; diameter of upper portion, about 27 mm. Another example is about 25 mm, in diameter; height of expanded upper portion 10 mm.; diameter of stem where it is broken from the body of the sponge, about 11 mm. The form of this specimen appears to have been very much like that of *Z. typicalis* var. *pistilliformis*, figured on the same plate with this species (Pl. V, fig. 4,).

The distinguishing characters of the species are found in the wavy and inosculating surface channels, and the generally wider interspaces. The form of the sponge approximates to that of *Z. typicalis* var. *pistilliformis*, but none of the four specimens are so much expanded above. A comparison of their respective surface channelings will readily distinguish them.

Position and locality: Twenty-five feet above the base of the Trenton limestone near Dixon, Ill.

Edriospongia nov. gen.

Sponge massive, lobate, attached by a broad base, with the sides irregularly indented. Canal system irregular, consisting of closely arranged radiating canals, connected by tortuous vertical canals passing through them. Minute canals, formed by the arrangement of the spicules in linear series, traverse the sponge in a direction parallel with the radiating canals. When perfect the sides of the sponge are covered with a minutely porous dermal layer. When this is removed the irregularly arrayed apertures of the radiating canals are exposed. Spicular structure between the canals, of unequal thickness, usually narrow.

The distinguishing characters of this genus may be summed up as follows: (1) The massive form, (2) broad base, (3) absence of stellate oscula and vertical cloacal tubes, and (4) the irregular arrangement of the canals, when compared with those of *Anthaspidella* and *Zittelella*. From *Streptosolen* the genus is separated by the three peculiarities first noted, as well as by the smaller and less tortuous radiating canals.

EDRIOSPONGIA BASALIS U. & R.

Pl. VI, fig. 1, 1a, 1b, 1c.

Sponge massive, irregular in outline, and attached to foreign bodies by a broad base; the sides are irregularly and often deeply indented, so as to impart to the mass a rudely pillared aspect. Upper surface with irregular depressions, but without oscula save those of the radially arranged vertical canals. These usually alternate with the radiating canal furrows, and form close series between two of the latter. Five or six mouths occur in the length of 5 mm., while the diameter of each is about 0.6 mm.

Upon grinding the surface it will be noticed that the radiate furrows are replaced by rows of vertical canal apertures, and the series of the latter by radiating canals. This changing from one to the other repeats itself if the grinding is continued, and proves that the two sets of canals pass through each other, and are alternately developed at the surface. The sides of the sponge, when the dermal layer is removed, often show the subcircular mouths of the radiating canals arranged in irregular vertical series. Portions of the more or less tortuous vertical canals also may be presented to view. Generally, however, the sides present a very irregular network of canals.

Height of largest example varying between 18 and 40 mm.; greatest width about 90 mm.

The three specimens of this species contained in the collection before us, are in too poor a state of preservation to admit of satisfactorily determining all the details. One of them is very deceptive, as it is attached to the lower surface of a species of *Anthaspidella* and has adapted itself so neatly to it that the osculiferous face was supposed to belong to the *Edriospongia*. This mistake was not discovered till some time after the specimen had been lithographed (Pl. VI, fig. 1, 1a) and the plate printed, It then occurred to us to saw the perplexing specimen vertically through the centre. When this was accomplished the duplex character was made manifest, as the section clearly shows a divisional line between the two sponges. Another difficulty, now presented, was to determine whether the *Edriospongia* had grown upon the *Anthaspidella*, or the former been accidentally deposited upon the upper surface of the latter. All the facts seem to point to the second explanation as the true one. Every character of the lower surface of the specimen as it is represented by fig. 1a, brings evidence against the conclusion that we are dealing with the upper surface of the sponge, but on the contrary, agrees in every respect with our idea of the base of a parasitic sponge. It therefore appears that during the lifetime of the *Edriospongia* the *Anthaspidella* was deposited upon its upper surface, without seriously interfering with the functions till the gradual increase of the sponge mass had stopped the water circulation by closing the canal outlets.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Illinois.

Streptosolen nov. gen.

Sponges simple or compound, obconical, pedunculate. Central oscula showing the mouths of five or six thin walled tubes, which extend through the sponge to the base. The oscula are surrounded by an irregularly radiating series of large canals; between these are also a few apertures of vertical canals. Sides of sponge with very irregular branching canal furrows. Minute structure of skeleton like that of *Zittelella* and *Anthaspidella*.

The character principally relied upon in distinguishing this genus from *Anthaspidella*, is found in the very irregular disposition of the canals. The radiating canals are not, as in that genus and *Zittelella*, arrayed in vertical series, but pass through the sponge mass in every direction, and the vertical furrows, so characteristic of those genera, are therefore wanting.

STREPTOSOLEN OBCONICUS U. & E.

Pl. IV, fig. 4, 4a, 4b.

Sponge obconical, gradually widening above the strong and slightly expanded base. Upper surface flat or slightly depressed with the margin rounded. The collection contains two specimens of which the smaller one was figured. This has but one osculum, sub-centrically situated, and around it a number of tortuous interrupted and branching radiating canals. The larger specimen has three oscula, each of which is surrounded by its own irregular system of radiating canals. The average width of the canals is about 1.2 mm. The sides of both specimens present a very irregular system of tortuous branching canal furrows. Near the base of the larger specimen there are evidences of a dense dermal layer. The dimensions of this example are as follows: height 75 mm.; greatest width about 60 mm.; diameter of stem 17 mm. by 24 mm.

None of the associated sponges resemble this species sufficiently to necessitate detailed comparisons. The irregular intertwining of the canals will distinguish it at a glance.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Illinois.

CALATHIUM?? (?ZITTELELLA) INFELIX U. & E.

Pl. V, fig. 1, 1a.

Of this species only two imperfect examples have been observed, but as they seem to be quite different from any of the associated sponges, it was deemed advisable to name and illustrate them. The form is obliquely conical, about as wide as high; the cup very deep, with the margins rounded. Sides of cup presenting the apertures of large radiating canals, arranged serially in the bottom of vertical channels, four or five in 10 mm. The outer surface of the sponge wall is much weathered, but preserves enough to show that though the radiating canals pass through the wall they are less regularly arranged here than on the inner surface. The spaces between the canals are poriferous, but the form of the spicules could not be determined. with certainty. A transparent section seems to show, however, that they are not unlike those of the ANTHASPIDELLIDÆ. Sponge wall gradually increasing in thickness from below upwards. The greatest thickness, 10 mm., is in the upper one-third of the height.

This sponge is placed provisionally in the genus *Calathium* of Billings, because it is most probably congeneric with his *C. canadense*, from the Chazy. Question signs are added because we believe *C. formosum*, the type of the genus, is generically distinct from these forms, but till the spicular structure of the various species has been determined, it will be impracticable to separate the groups. Perhaps the genus *Zittelella* should be extended so that it would include species of this type.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Illinois.

HINDIA INÆQUALIS U. & E.

Pl. II, fig. 4, 4a, 4b.

Sponge free, of spherical form, with the surface evenly rounded. The diameter of the largest specimen is 13 mm. Other examples apparently belonging to the same species, vary from 7 to 10 mm.

The centre of the sponge is occupied by loose tissue, from which extend small straight canals to all parts of the surface. The radiate canals increase in number, and very slightly in size, as the sponge grows larger, are sub-circular in section, and vary in width from 0.2 to 0.7 mm.; their walls are thin and consist of cemented spicules. The skeleton, being calcified, gives but a faint idea of the individual spicules.

The internal character of the species, as they appear in thin sections, are well shown in figs. 4a and 4b. In transverse sections, the angles of junction between the canals, are alternately composed of: (1) clear crystalline calcite, representing the nodes of the spicules, and (2) the matrix which passes through the connecting pores. In fig. 4a the latter are represented by a darker shade. It would, perhaps, have been better to have left them out of the drawing altogether, as the irregular shading by which we intended to imitate the limestone matrix, might be interpreted to represent details of skeleton structure not intended.

The distinguishing feature of this species is found in the unequal size of the radiating canals. The larger ones are generally surrounded by one or two series of the smaller canals, but their arrangement with relation to each other is quite as variable as their width.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Illinois.

STROTOSPONGIA nov. gen.

Sponges compound, funnel-shaped, composed of thin, intricately intertwined vertical leaves. The upper surface with more than one osculum, around which the undulating vertical leaves are arranged in a radiate manner. Cloacal depressions of variable depth; the apertures of several vertical tubes occupy the bottom of each. Lower or outer surface with large sub-circular and closely arranged canal apertures, arranged in somewhat regular longitudinal series, while the interstices between them are occupied by smaller canal apertures of variable size and form.

Vertical sections show that the sponge wall is travered by labyrinthically intertwined canals, having irregularly perforated thin walls.

Owing to changes produced during the process of fossilization the minute structure of the canal walls cannot be determined satisfactorily. Where the walls are thinnest, traces of the spicules are preserved. They appear to have been very minute, and mainly three-rayed. Also a few extremely small uniaxial spicules seem to belong here.

In the form and general aspect of the sponge, *Strotospongia* resembles species of *Anthaspidella* so closely, that the utter disagreement in their respective internal structures (so far as it has been determined) is very surprising. On the other hand, we are again surprised to find that the internal structure of *Strotospongia* corresponds very closely with that of the massive sponges for which Mr. S. A. Miller proposed the genus *Dystactospongia*. Both of these genera, we believe, belong to the CALCISPONGIÆ, which they resemble more than any other group of sponges. At any rate, none of the characters so far determined present any serious objections to our view, but on the contrary all seem to justify a provisional classification with the calcareous sponges.

STROTOSPONGIA MACULOSA U. & E.

Pl. VIII, fig. 1, 1a, 1b, 1c, 1d,

Sponge depressed funnel-shaped, expanding rapidly above the sub-cylindrical stem, which is of unknown length. Upper surface concave, with the margin acutely rounded. Near the centre there is a deep cloacal cavity or osculum, while six others, of smaller size, and less deep are situated at varying distances from the central osculum. Around each there is a series of thin-walled canals, arranged in a radiate manner, from 1 to 1.5 mm. wide. The radiating canals extend but a short distance from the oscula when they bend downward and are lost in the confused plexus which prevails throughout the interior of the sponge. Beyond them the thin sponge substance forms a very irregular network, with large angular meshes.

The under surface exhibits the apertures of numerous canals, 0.7 to 1.2 mm. in width, which are arranged in subregular longitudinal series on the expanded portion of the sponge. On the surface of the stem their arrangement is much less regular, while they are also somewhat larger and more angular than those occupying the space for some distance above the stem. Here their mouths are sub-circular, and separated by sponge tissue less than half their diameter in width. Near the margin of the upper surface the canal apertures again become more angular, and the sponge substance thinner. Numerous smaller canal apertures occupy the spaces between the larger canals.

A vertical section shows that the sponge walls are traversed by labyrinthically intertwined canals. The separating sponge substance, which is generally not more than 0.1 mm. thick, has been replaced by crystalline calcite, and the process has effectually destroyed nearly all the finer details of structure. Where the walls are thinnest, or less compact than usual, obscure traces of the spicules and sponge fibre are preserved. So far as the unsatisfactory conditions will admit of determining their characters, it seems that the fibres contained both three-rayed and uniaxial spicules.

The above describes the characters of the specimen we have illustrated. The collection contains, besides, two other examples which differ considerably in the size and arrangement of the canals, and may belong to another species of the genus. Although we were tempted to add another species to this peculiar genus, we have concluded to await the discovery of other specimens, before deciding them to be distinct.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Illinois.

DYSTACTOSPONGIA MINOR. U. & E.

Pl. VIII, Fig. 3, 3a, 3b.

Sponge lobate massive, composed of irregular vertical leaves, which combine to form a tubular mass. The tubes or canals radiate from the base to the upper surface of the specimen, where their walls, which have a thickness varying from 0.1 to 0.4 mm., present the appearance of short, beaded lines of calcite, forming an incomplete net work, with small and irregular meshes, not exceeding, apparently, 1 mm. in width.

In vertical sections the canal walls decrease slightly in thickness from below upwards. They are pierced at frequent but unequal intervals by large irregular openings. The canal cavities are traversed by fine branching or simple fibres of calcite, which we suppose to represent spicules. In transverse sections the sponge substance is represented by small irregular masses of crystalline calcite.

Of this species we have seen only the small lobate example, illustrated on plate VIII.* The figure gives an oblique view of the specimen and shows, on the left side, vertical canals running from the base to the rounded upper surface. The vermiculate lines on the half to the right, represent their incomplete walls. On account of the great irregularity of the internal structure, it is difficult to draw up satisfactorily descriptions of the species of this genus. The same difficulty is experienced in describing the internal construction of *Strotospongia*. The structure of these sponges might, perhaps, have been better defined by saying, that the sponges are composed of irregular reticulate fibres so arranged that they form labyrinthically intertwined canals, or, more or less irregular, vertical tubes.

Position and locality: Twenty-five feet above the base of the Trenton limestone near Dixon, Ill.

DYSTACTOSPONGIA RUDIS U. & E.

Pl. VIII, Figs. 4–4a.

Of this species also, the collection contains but one example. This is massive, of oval shape, three and one-half inches long, two and one-half inches wide, and one and five-eighths inches high. It is composed of reticulate sponge fibre arranged in such a manner that it forms very thin, cribrose leaves, .1 mm. or more in thickness, which combine with each other at unequal intervals, so as to produce an irregularly tubular mass. The canals so formed vary in width from 1.5 mm. to 4 mm., and traverse the mass in an irregular radiate manner from the base.

*Since this was written Mr. E. O. Ulrich visited Dixon and succeeded in collecting several other specimens of this and the following species. These agree in all respects with the ones described.

In sections the cribrose character of the intertwining sponge leaves is quite obvious, but the component parts of the fibres have been so much obscured during fossilization, that they cannot now be determined. But in the matrix which fills the canal cavities, a large number of minute needle-shaped bodies, as well as a few three-rayed forms, were observed.

This distinct species is separated from *D. minor* by the thinner leaves, and much larger canals. From *D. insolens* Miller, the type of the genus, it is distinguished by the same characters. That species also presents a limited number of large radiate oscula on the upper surface, which are not observable on the species here described.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Ill.

CAMAROCLADIA nov. gen.

Sponges consisting of small subcylindrical branching stems. Interior with comparatively large, but short sub-cylindrical canals, or cavities, which wind about in an irregular manner before opening at the surface of the branches. The canals are separated by thin cribrose walls.

The walls are now composed of crystalline calcite, and preserve only very faint traces of the spicular fibre. In the canal cavities a number of minute, mainly isolated three-rayed forms were observed.

This genus is proposed to include small branching fossils that are quite numerous in the Dixon sponge layer. In their general appearance they resemble species of *Buthotrephis*, a genus of the so-called "Fucoids." Whether any of these supposed plants are really fossil Algæ remains to be seen. That many are not, will be shown, we think, when their obscure remains are examined and studied as they should be.

Some will probably turn out to be inorganic, others may be trails and burrows, while not a few will prove to be sponges, as has already been shown of *Dictyophyton* and *Cyathophycus*.

The systematic position of *Camarocladia*, while not positively determined, is nevertheless, sufficiently indicated by the known characters, to induce us to classify the genus with the calcareous sponges, in the neighborhood of *Peronella* and *Verticillites*.

CAMAROCLADIA DICHOTOMA U. & E.

Pl. VII, Figs. 1, 1a, 1b.

Sponge ramose, branching dichotomously at intervals of 10 mm. (more or less). Branches sub-cylindrical, 2 mm. or a little more in diameter, with the surface smooth or minutely roughened, and irregularly porous. Among the minute pores, which we regard as interstices between the reticulate skeleton fibre, a small number of larger ones may be detected.

Sections show that the interior of the branches is mainly occupied by more or less confluent short sub-cylindrical cavities, with the separating partitions very thin. The cavities seem to wind about in an irregular manner before they open at the surface. Their width varies but little from 0.4 mm.

The cluster of branches shown on plate VII, illustrates the usual appearance of this peculiar sponge. The branches are generally matted together and much broken in the rock or on the surface of *Anthaspidella* species. In this condition the specimens rarely show any recognizable structure.

There are, probably, two or three other species of this genus in the Trenton rocks of the western states. Though very abundant in certain layers, the conditions of preservation were in every case so unfavorable that none of the specimens preserve more than the merest traces of the sponge skeleton. Two of them are more robust than *C. dichotoma*, while the third is a smaller form and its branches divide more frequently.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Ill.

STOMATOPOROIDS.

ACTINOSTROMA? TRENTONENSE U. & E.

Pl. VII, Fig. 3, 3a, 3b.

The specimen which we propose to designate as above, is a rounded sub-hemispheric mass, 47 mm. in diameter, by 23 mm. in height. It consists of superimposed layers, from 1 to 3 mm. thick.

Sections are somewhat obscure, but show that the mass is composed of minute irregular vertical rods, of stellate form in cross section. At varying intervals the rods throw out from four to six slender rays which may or may not unite with the rays of the surrounding rods.

In its minute structure this fossil resembles the ANTHASPIDELLIDÆ, but the fact that the hemispheric mass is made up of superimposed layers, seems to indicate a more decided affinity with the Stromatoporoid section *Actinostroma*, proposed by Dr. Nicholson. The typical species of *Actinostroma*, one of which is illustrated on plate VII, differ from our species in having the rays of the "radial pillars" placed at corresponding levels. Up to the present time the genus was not known to have representatives in older rocks than those of the Wenlock limestone of Britain. From that horizon two species are mentioned by Dr. Nicholson. In Devonian deposits the species are more numerous.

Position and locality: Twenty-five feet above the base of the Trenton limestone, near Dixon, Ill.

PART II.

PALÆONTOLOGY OF ILLINOIS.

SECTION VI.

Palæozoic Bryozoa.

By E. O. ULRICH.

LETTER OF TRANSMITTAL.

To Prof. A. H. Worthen, State Geologist:

DEAR SIR: When I undertook this work it was with the intention of preparing a complete monograph of the Bryozoa found in the Palæozoic rocks of the State. It soon became apparent, however, that this could not be carried out, since the class proved to be so numerously represented that neither space nor the appropriation would suffice for the purpose. In view of this I decided to select only the typical and most important species and upon these to base a system of classification enabling the student without much trouble to arrange his long neglected material. To facilitate the study I found it necessary to write a comprehensive introduction, containing a short bibliographic sketch of the subject to date, an account of the general and comparative structure of Palæozoic Bryozoa, and a chapter on their classification with notes upon recent methods of investigations. My classification is based almost entirely upon the microscopic and really fundamental characters and I need not therefore apologize if my system differs widely from those hitherto employed. The time has arrived when some convenient and natural arrangement for this large branch of the Palæozoic fauna is not only desirable but a pressing necessity if we would use them to further the progress of stratigraphical geology. There is no class of fossils better entitled to that distinction than the Bryozoa, as they are more than usually persistent in their characters. Those of the suborder TREPOSTOMATA are even servicable where other fossils are too imperfect, since in most cases they can be identified by means of thin sections.

The material upon which the present report is based is mostly contained in the State Museum at Springfield. A few illustrative species not in the museum were loaned for description from private collections. Of these, whenever possible, I have placed typical examples into the State collection, so that it may be claimed with truth, that as a collection of Upper Palæozoic Bryzoa at any rate, it stands unsurpassed. The numerous thin sections required for the work, were all personally prepared by me. The illustrations, too, have all been drawn, and many of them transferred to stone, by myself. On the remainder the lithographic work was done, under my personal supervision, by Mr. Charles Schuchert, to whom I am much indebted for the fidelity and skill he has shown in the performance of his difficult task.

To Mr. J. M. Nickles of Sparta, Illinois, who has not only amassed a large collection of Palæozoic Bryozoa but also is conversant with their structure, I am especially indebted for much valuable assistance both by way of advice and specimens.

And to you, my dear sir, I cannot sufficiently express my gratitude for the encouragement and many kindnesses that I have received at your hands, nor can I forget the marked patience and sympathy that you have shown me throughout the progress of my work.

Very respectfully yours,

E. O. ULRICH.

PREFACE.

For reasons pointed out in my letter of transmittal, the present work falls considerably short of being a "Monograph" of the Palæozoic Bryozoa of Illinois, and much unwrought material still remains in the State Museum. Many new and important forms are also contained in private collections, while in my own there are over two hundred Palæozoic species (many of them from Illinois) that must await opportunities for publication. This, however, was not so much a cause for regret as the loss of much time that was consumed in selecting just such forms as would show the characters and limits of the genera in the best manner. My desire to establish the generic divisions in such a manner that they would readily appeal to the mind of the student I sought to fulfill by incorporating into the report as many diagnostic species as possible. On this account the plates, especially the latter ones, are more crowded, and some of the species less fully illustrated, than I had originally intended. The crowded condition of the plates, on the other hand, bears witness to the fact that I have done what I could in the way of illustration, and in most cases, I have no doubt, it will be found to suffice for present needs, or until a "Monograph" of the Palæozoic representatives of the class can be prepared.

Palæontologists have now universally conceded that in the determination of such difficult groups of organisms as the fossil Bryozoa the microscopic structure is the most essential element. The superficial characters may vary greatly in differently preserved specimens, or they may not be recognizable, while the mere external form or habit of growth is too treacherous a guide to be relied upon. The older palæontologists, without exception, relied upon these delusive external characters in distinguishing their species, and the result is that it is now almost impossible to identify a large number of forms which they have described and named. Their names have become current, but we have no assurance that we are really dealing with the forms to which the names were originally applied. Frequently, too, the names have been applied by subsequent observers to totally different organisms, so that no little amount of confusion has resulted. The ill effects of this state of things upon stratigraphical geology, can scarcely be exaggerated, since it is often quite impossible to be sure of the identification by various authors of the characteristic fossils of particular horizons. Thus, one often finds *Chætetes lycoperdon* Say, *Stenopora fibrosa* Goldfuss, *S. columnaris* Geinitz, and *Monticulipora* or *Chætetes petropolitanus* Pander, quoted in lists as typical fossils of certain stratigraphical horizons; but it is safe to say, that in almost every instance there is no surety that the indentification of the species rests upon anything beyond the worthless characters of external form and general composition.

This confusion will continue so long as such illy characterized and unidentifiable species are recognized by palæontologists.

Some indulgences might be extended to early authors but I hold that there is absolutely no excuse whatever for such work at the present time when our facilities for giving our work a permanent value, by doing it well, are so much better than they were in former years. Of greater value, at present, than the mere addition of new species to our lists, is the proper elucidation of those already named.

Until within the last ten years the Palæozoic Bryozoa did not receive the attention from palæontologists that they deserve, and previous to 1875, Dr. Hiram A. Prout was the only American author who aimed to introduce some system into their classification. Unfortunately, his labors were almost exclusively confined to the Bryozoa of the Carboniferous rocks, and consist mainly of careful delineation of species and genera. On account of his limited acquaintance with the Silurian, Devonian and Mesozoic forms, his conclusions were often faulty. However, when we consider the time and the primitive methods of investigation then employed, we are forced to credit him with fine powers of discrimination and observation. To Dr. H. A. Nicholson the student of Palæozoic TREPOSTOMATA is more indebted than to any other naturalist, since to him belongs the credit of being the first to recognize the absolute necessity of thin sections. His works mark a new departure, an epoch in the study of these intricate fossils, and it is upon the outlined basis first drawn by this brilliant naturalist, that my own work has been built. We agree admirably upon fundamental principles and the facts involved, and if we differ more or less in our conclusions, I think it is mainly because Dr. Nicholson has not gone into the comparative anatomy of the subject as deeply as I have found it necessary to do. Nor can he have had any adequate idea of the vast variety and number of the forms under consideration.

To enhance the value of my work I have extended my investigations so as to embrace not only Palæozoic, but also all available Secondary, Tertiary, and recent material. The exhaustive works of D'Orbigny, Busk, Reuss, Manzoni, Hagenow, Hincks and other authorities on the subject, were carefully studied and searched for information which might throw some light upon the early representatives of the class here treated. Much success has attended my endeavors in this direction and the classification now offered, though essentially the same as the scheme published in my "American Palæozoic Bryozoa," is nevertheless much improved and more natural, as the whole is based upon the microscopic and really fundamental characters of the organisms. Nearly four thousand thin sections were prepared, illustrating the internal characters of between six and seven hundred species.

It is not claimed that the system adopted applies correctly in all cases, but I am convinced that the outlines as herein drawn will recommend themselves to all who will undertake the study of the Palæozoic Bryozoa with an unprejudiced mind and a firm determination to master them. Such a student will quickly learn that, as soon as he has accustomed himself to taking note of every variation, and grasped the fundamental principles of the system, the subject is less difficult than it at first seemed, as he will find that his specimens usually drop naturally enough into their proper divisions. In the chapters on general structure and classification some notes on methods of investigation may prove of interest and, perhaps, of value.

An abridged bibliographical sketch, as well as a chapter on comparisons between Palæozoic and more recent Bryozoa, has been prepared, but on account of a lack of space they could not be printed in this volume.

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 the FISTULIPORIDÆ and other Palæozoic Bryozoa.

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

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. STICTOPORIDÆ). 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 surface of the zoarium in which the embryoes are developed, or a special receptacle 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.

CYSTIPHRAGMS:—The convex plates which line the walls of the zoœcia in some of the TREPOSTOMATA.

OPERCULA OF PERFORATED DIAPHRAGMS:—Horizontal plates, perforated subcentrally, closing the mouths of the zoœcia. As growth proceeds in the colony these are left behind in the tubes and mark the successive stages.

SUPERIOR HEMI-SEPTUM:—A plate or laminar projection which forms the posterior border of the primitive zoœcial aperture, in the typical CRYPTOSTOMATA.

INFERIOR HEMI-SEPTUM:—A small plate often present in the CRYPTOSTOMATA, springing from the anterior wall or the medium laminæ of double leaved forms, at a point a short distance below the "Superior hemi-septum".

LUNARIUM:—A more or less thickened portion of the posterior wall in many Bryozoa which is curved to a shorter radius and usually projects above the plane of the zoœcium aperture. It is of crescentic form, and represents the "notch" which is such a characteristic feature of the aperture of some of the recent CHEILOSTOMATA. In the Palæozoic Bryozoa it is variously modified and drawn out trough-like.

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

SECONDARY OF SUPERFICIAL APERTURE:—The superficial orifice of the tubular prolongation 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, and developed at regular intervals. The rounded, hexagonal or quadrate meshes of the net work thus formed are known as the "fenestrules".

CHAPTER I.

GENERAL AND COMPARATIVE STRUCTURE OF PALÆOZOIC BRYOZOA.

To get a correct idea of the structure of Palæozoic Bryozoa, it is absolutely necessary that they be studied with the aid of thin sections.

The following is a simple method for preparing 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 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 is 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, 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 Canada balsam allowed to boil 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 may be covered with a thin sheet of glass, or only a film of balsam, when it is again heated and the air bubbles, if any are present, expelled by faint pressure upon the section with some pointed instrument.

Of course it requires a certain amount of experience and time to make good sections, yet even the beginner ought soon 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 which will become apparent to the reader further along, 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, with very thin walls, and more or less nearly vertical, 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 paralled 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 heights.

I. *Mode of growth.*—In considering the general structure of fossil Bryozoa, the mode of growth and the form ultimately assumed by the zoarium, though generally of but sub-ordinate classificatory value, may very appropriately be mentioned first. The outward form of the zoarium, though extremely variable, when the whole class is taken into consideration, is tolerably constant for each species, and not infrequently all or most of the species belonging to one genus may adhere more or less strictly to some particular method of growth. The importance of variation in outer form as a factor in classification is very much diminished by the fact that many species may vary considerably in shape, and but very slightly in their minute structural characters, while on the other hand structurally diverse species may assume the same outward form. We must admit, however, that in many Bryozoa the ultimate form of the zoarium is largely determined by the shape and reproduction of the zoœcia, and in these the external form is of the first importance, since it is indicative of variations in structural characters.

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

1. The *incrusting* or *parasitic* zoarium, in which the colony is parasitically attached by the whole of the lower surface to foreign bodies, such as shells corals other Bryozoa or stones. The zoœcia are short, usually tubular, and by the formation of successive layers the zoaria may form large masses. Examples are several species of *Leptotrypa*, *Spatiopora*, *Palæschara*, *Atactopora*, *Ceramoporella*, *Eridopora*, *Stomatopora*, etc.

2. The *laminar* zoarium, differs from the encrusting only in being free and in having the lower surface covered with a wrinkled or striated epithecal membrane. The colony usually commences its growth upon some small object. This type of

growth is represented by many species of *Fistulipora*, *Monticulipora cincinnatiensis* Nicholson, and several species of *Stenopora*.

3. The *massive* zoarium, which may be free, attached only at the base, or growing around some foreign body. The zoœcia form long tubes, divided at more or less frequent intervals by diaphragms. The massive zoarium is seen in *Monticulipora mammulata* D'Orbigny, some species of *Leptotrypa*, *Monotrypa*, *Fistulipora* and *Crepipora*.

4. The *discoid* zoarium has the form of a plano-convex or concavo-convex disc. Generally the convex surface is celluliferous and the flat or concave surface covered with a striated and wrinkled epitheca. *Monotrypa? petasiformis* Nicholson, *Leptotrypa discoidea* Nich., *Diplotrypa petropolitana* Pander, and *Prasopora lycoperdon* are examples. More rarely the upper or celluliferous surface is concave or flat, and the lower side convex. Of this condition *Scenellopora radiata*, and *Proutella discoidea* (Prout sp.) examples. The same type of zoarium pertains to species of *Aspidopora*, *Discotrypa* and *Cyclopora*, but in these the height when compared with the width is proportionately much less than in the examples first cited. In all, the adult form was essentially free, but that the majority were originally attached to some small foreign body usually admits of demonstration.

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 foliate expansion, or of flattened branches. This type of growth is very common, being characteristic of the PTILODICTYONIDÆ and STICTOPORIDÆ. Among the CYSTODICTYONIDÆ, *Prismopora*, *Glyptopora* and *Evactinopora* offer peculiar modifications of this type of growth.

6. The *dendroid* or *ramose* zoarium, in which the entire free surface is covered by the apertures of zoœcial tubes, is very common among the TREPOSTOMATA. The tubes radiate in all directions from an imaginary axis, or from an axial tube. A ramose zoarium is seen in *Rhombopora*, *Batostomella*, *Amplexopora*, *Monotrypella*, *Diamesopora*, *Nematopora*, etc., etc.

7. The *frondescent* or *palmate* zoarium is intimately connected with the ramose, the arrangement of the zoœcia being the same. It usually consists of leaf-like expansions with the edges rounded and celluliferous. Good examples are *Heterotrypa frondosa* D'Orbigny, sp., and *Homotrypa dawsoni* Nicholson.

8. The *segmented* zoarium is characteristic of a number of Palæozoic Bryozoa. In these the complete zoarium is composed of more or less numerous, simple or branched segments, with each end slightly bulbous and subsolid. This type of growth is seen in *Arthrostylus*, *Arthropora*, *Arthroclema*, *Dicranopora* and *Helopora*, all Silurian genera. It has also been observed in a new form from the Hamilton group of New York.

The species of *Ptilodictya* may also be included with the segmented Bryozoa, since the basal extremity of the zoarium in this genus is pointed and was inserted in the socket-like depression of an attached basal expansion.

9. The *fenestrated* zoarium, in which the colony is composed of slender branches, celluliferous on one side, which anastomose with each other as in *Phyllopora* and *Phylloporina*, or are united at regular intervals by non-poriferous processes (dissepiments) the whole forming a flabellate, spiral or infundibular expansion. *Fenestella*, *Polypora* and *Semicoscinium* are examples.

Archimedes and *Lyropora* are modifications of this type of growth. In the first there is a solid spiral axis; in the second two strong diverging supports, between which the reticulate expansion is spread.

10. The *pinnate* zoarium differs from the preceding in being composed of a straight central branch and more slender lateral branches, which spring from the sides of the main stem. *Acanthocladia* and *Pinnatopora*.

II. *Surface characters.*—Aside from the superficial characters of the zoœcia, which will be treated in another place, the surface of a large number of Palæozoic Bryozoa presents certain peculiarities, which, on account of their conspicuousness, demand special consideration. Foremost among these are the structures commonly known as "monticules" and "maculæ" which, though properly enough applied to designate distinct conditions, are morphologically the same. In a strict sense the "monticules" are circumscribed areas on the surface of the zoarium which are elevated to a variable degree above the general level and constitute a more or less regularly distributed series of conical rounded or elongated eminences. Usually the "monticules" are occupied by zoœcia more or less decidedly larger than those of the average size in the intervening spaces, though in some cases the difference in this respect is quite inappreciable. Apparently always, however, the cells on the monticules are distinguished by some peculiarity, so that if they are not larger they may be recognized by their thicker walls, or by the greater width of the spaces between them. Monticules having the structure here described are present in *Monticulipora mammulata* D'Orb., *M. cincinnatiensis* Nicholson, *Callopora ramosa* D'Orb., *Monotrypa? filiosa* D'Orb., *Discotrypa elegans*, *Spatiopora montifera* and *Homotrypa dawsoni* Nicholson.

The "maculæ" like the "monticules" are circumscribed spaces on the surface of the zoarium, but differ from them in being composed of aggregations of mesopores or vesicular tissue, instead of groups of large zoœcia. It is a fact, however, that the zoœcia which surround the "maculæ" are almost invariably appreciably larger than those farther removed from the centre of a "macula." The surface of the maculæ may be finely porous (e. g. *Heterotrypa subpulchella* Nicholson, *Crepipora impressa*), with the mesopores visible but closed (e. g. *Dekayella obscura* and *Peronopora decipiens* Rominger), apparently solid and elevated above the general level of the surface (e. g. *Atactopora maculata*, *Crepipora solida*), or smooth and depressed. The last condition is the most typical and common, and is represented in a more or less marked manner by all of the FISTULIPORIDÆ, and many of the CYSTODICTYONIDÆ. In these families the interspaces between the zoœcia are occupied by lenticular vescicles which, at any rate in the perfect adult state, are not visible at the surface. The "maculæ" are depressed, often stellate and quite regularly arranged, when they impart a very characteristic and ornamental appearance to the zoarium. Though of rare occurrence, "maculæ" are also occasionally present among the STICTOPORIDÆ (e. g. *Pachydictya* and *Phyllodictya*), but the non-poriferous margin, which is so characteristic a feature of the zoarium of that family as well as of the PTILODICTYONIDÆ and CYSTODICTYONIDÆ, is essentially the same thing, since its minute structure is precisely similar to that of the maculæ. The non-poriferous margin further agrees with the "maculæ" in the fact that the zoœcia which are nearest to the margin are almost invariably larger than those occupying the central region of the stipe. In *Prismopora serrata* Meek, and *P. trifolia* Rominger, the morphological identity of the non-poriferous margin and the "maculæ" is clearly shown, the two being confluent.

As regards the uses of the "monticules" and "maculæ," the only suggestion that seems at all applicable, is that they had something to do with the reproductive functions. The large cells which occupy the monticules or surround the maculæ must in that case have been the receptacles in which the embryo were developed into the larval stage. This explanation is made very plausible by a comparison with the *gonœcium* of *Crisia*, which is nothing more than a slightly modified zoœcium set apart for reproductive functions. The oœcium of many other Cyclostomatous Bryozoa is simply an inflated Zoœcium, which also may be slightly modified in other respects. In *Strotopora*, a new genus of the FISTULIPORIDÆ, the surface exhibits more or less numerous cells which are curiously modified in having the apertures abruptly expanded to two or three times the normal width. In the perfect state the aperture is arched over and presents the appearance of a small vesicle. That these structures represent oœcia will scarcely admit of doubt.

III. *Mesopores and vesicular tissue.*—The term "Mesopores" was proposed by Nicholson and Foord for the cells which occupy the spaces between the true Zoœcia previously known as interstitial cells and cancelli.* They applied the term equally to the interstitial tubes of *Callopora*, *Prasopora*, *Diplotrypa*, *Heterotrypa*, etc., and to the vesicular cells of *Fistulipora*. These structures are, however, very distinct and ought to be known by different names. I propose, therefore, that the use of the term "mesopores" be restricted to the tubular interstitial cells,

* Prof. Busk and other authors applied the name "cancelli" to the interstitial tubes of *Heteropora* and other Bryozoa of that type. Mesopores is supposed to be a more appropriate term, and is used by me in its stead.

and that the lenticular vesicles provisionally retain the more appropriate designation "vesicular tissue."

In this restricted sense the mesopores are tubular cells occupying the interspaces between the true zoœcia. Their number and size varies greatly in different species, being quite variable even in species of the same genus. In some they are very small and occur only at the angles of junction between the zoœcia, while in other forms the latter are completely separated from each other by one or more series. When closely examined they are found to be, perhaps in all cases, more or less decidedly angular and of irregular shape, though it is not infrequently found that the angles are blunted and the cavity rounded by an internal deposit of sclerenchyma. This is the case in all those forms in which the cell walls are thick. Numerous examples might be cited, but *Stictoporella* and *Batostomella* will suffice. In longitudinal sections the tubes of the mesopores are generally distinguished from the true zoœcia by their comparatively more numerous diaphragms, which are always horizontal and "complete." From a morphological point of view the most important character of the mesopores is found in the fact that they do not occur in the axial region of the zoarium, but first make their appearance in the cortical portion after the original zoœcia have commenced to bend outward (or upward as the case may be) in their course to the surface.

The structure known as "vesicular tissue" is composed of lenticular cells, which fill the interspaces between the zoœcia in the FISTULLIPORIDÆ and CYSTODICTYONIDÆ. Unlike the mesopores they originate already in the axial region, being, however, more numerous as well as smaller in the superficial portion of the zoarium. They are never arranged so as to form tabulated tubes like the mesopores, but occur in horizontal layers, the constituent cells of which are quite independent of those of the preceding layer. Near the surface of an adult zoarium they are largely filled with sclerenchyma, which more or less completely obliterates their individuality. This deposit, however, is traversed by minute vertical tubuli, that seem to serve the purpose of maintaining communication between the open cells and the surface to which their prominent terminations impart a minutely granular aspect. Vesicular tissue is also developed in the older regions of species of *Semicoscinium* between the "carinæ," and especially in the footstalk. The discovery of that structure in such unequivocal Bryozoa as the FENESTELLIDÆ is of the greatest importance in its bearing upon the question of the zoological position of the FISTULIPORIDÆ. In the proper place we will consider it in greater detail.

IV. *Acanthopores.*—A large number of Palæozoic Bryozoa, especially among the TREPOSTOMATA, present, when in a good state of preservation, a greater or less number of blunt spine-like structures, which are placed around the zoœcia apertures, usually at the angles of junction between adjoining cells. Sometimes they also occur at some point between the angles, while in other forms, notably such as *Leioclema* species, in which the mesopores are very numerous, they are apparently included within the substance of the walls of the zoœcia. These peculiar appendages present themselves at the surface as so many blunt projections, varying considerably in prominence and size in different species, In the genus *Dekayia*, they attain a greater size than in any other, being in some species almost or quite as large as an average zoœcium. Ordinarily they are much smaller than this, while in some forms they are so much reduced in size that it is difficult to distinguish them from the elevated surface terminations of the "median tubuli" (e. g. *Rhombopora* species, and *Leioclema? araneum*). Thin sections show conclusively that they were all originally hollow, and the apical aperture of the spines may in rare instance be detected. Generally, however, the summit of the spines appears to be solid, but this fact may be easily accounted for by the readiness with which the excessively minute apertures would be filled up by the matrix or by infiltrated calcite. As stated, sections prove beyond a doubt that we are not dealing with mere superficial ornaments, but that they extend into the substance of the peripheral region of the zoarium, in which they can be traced to a depth equal to that reached by the "mesopores". As seen in tangential sections they appear as circular spots of somewhat darker or lighter shade than the wall substance immediately surrounding them.

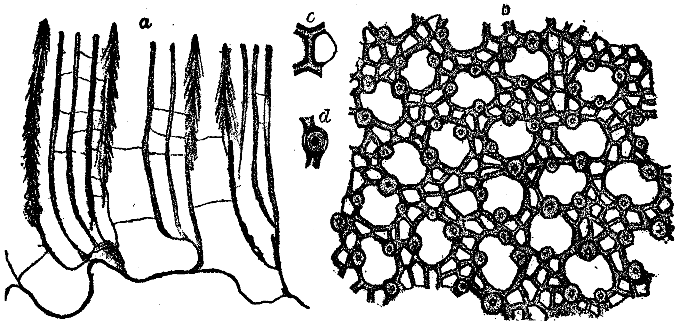

Fig. 1. *Leioclema foliatum*, Ul. Warsaw beds, Warsaw, Ill.—*a*, Vertical section x28, showing entire thickness of zoarium, tabulation of zoœcia and mesopores, and structure of the acanthopores; *b*, tangential section x28, showing distribution of acanthopores, mesopores and zoœcia; *c*, small portion of wall x50; *d*, acanthopore x50, showing its structure.

Further examination shows that they are composed of laminated sclerenchyma, disposed in a concentric manner around a circular clear or dark central space. In vertical sections the minute central canal is often clearly seen, as well as the structure of the thick walls. The concentrically laminated structure noticed in tangential sections proves to be produced by a succession of overlapping conical layers of sclerenchyma. This arrangement of the laminæ proves conclusively that the aperture of the spines was at all times approximately of the same diameter, and completely overthrows the supposition advanced by Dr. Nicholson ("The Genus Monticulipora", p. 47), that these spines were a peculiar form of corallites, the mouths of which became closed by secondary deposit as the corallum assumed its final characters. On the same page he also says: "It is not, of course, essential that we should suppose these singular structures to be occupied by polyps; but I think them to be modified zooids in the same sense as is true of the 'avicularia' of the Polyzoa". I am perfectly willing to accept Dr. Nicholson's view as it is expressed in the above quotation, since I am fully convinced that in the "acanthopores" we are dealing with structures that supported appendages most likely of identical nature and functions with the avicularia or vibracula found on recent Bryozoa. This explanation possibly applies only to the large acanthopores as they are seen in *Dekayia*, species of *Leioclema*, and other forms. The smaller and closely arranged ones, characterizing the genera *Batostomella*, *Amplexopora*, *Atactopora* and *Rhombopora*, were most probably occupied by somewhat different yet homologous appendages. These may find an explanation in the stout, chitinous or calcareous bristles which are found upon the walls of the zoœcia in many CHEILOSTOMATA. After the death of the zooid these bristles fall off, leaving minute pits in the summits of small blunt spines.

True acanthopores are also present in a large proportion of the FENESTELLIDÆ and ACANTHOCLADIIDÆ. In *Fenestella*, *Ptylopora* and *Septopora*, the mesial carina very often bears strong spines, which sections prove to have been hollow and constructed upon the same general plan as the "acanthopores" of the TREPOSTOMATA.

In *Polypora* and other genera having more than two rows of zoœcia they are distributed among the cells with greater or less regularity.

The apical apertures are not often preserved, but they are shown in a beautiful manner in specimens of several species described in this volume (*Fenestella wortheni*, Pl. 52, fig. 5, 5a, and *Ptylopora cylindracea*, Pl. 66, fig. 2). While I regard these "acanthopores" as probably having been occupied by vibracular structures, some other explanation seems necessary to account for the peculiar "dimorphic pores" occurring so abundantly upon the non-poriferous side of the branches in *Septopora*, *Acanthocladia fruticosa* and *Semicoscinium infraporosum*. These pores are also present on the celluliferous side of several species, where they are scattered among the zoœcia. In the species last mentioned, we find them on each side of the prominent mesial keel. These cannot have contained the same kind of modified zooid as the acanthopores, since they are generally much larger than the latter, and because in most cases (notably *Septopora biserialis* Swallow) both kinds of pores occur in the same species. If in the "acanthopores" we see the supports of vibracular structures, would it be unreasonable to suppose that the "dimorphic pores" were the receptacles of "avicularia"? I see nothing in their structure to negative the supposition, nor would these be the only instances in which both avicularia and vibracula occur together, as, according to Hincks, both kinds of appendanges are present in two genera of the CHEILOSTOMATA.

We now pass on to the consideration of other sets of minute tubuli, which, though often strongly resembling the "acanthopores", must have had very different functions. Until they are better understood I propose to designate them by the term "median tubuli", the name having reference to their position in the zoarium.

V. *Median tubuli.*—In its strictest sense the term applies to certain exceedingly slender longitudinal tubes which are present between the two median laminæ in many of the STICTOPORIDÆ. In *Stictopora* and *Pachydictya* they are of sufficient size to be recognized with ease in transverse sections. So far as observed here, they do not seem to be provided with distinct walls, but appear to have been produced by an equal longitudinal grooving of the laminæ, so that half of the tube is on each side of the divisional line between the laminæ. Another set, which I consider as essentially of the same nature as those just described, traverses the walls of the zoœcia (or the interspaces between them) in a vertical direction. These are arranged in crowded series and very much resemble small "acanthopores". In *Stictopora* and some species of *Pachydictya* they are usually arranged in a single series along the middle of the walls between the zoœcia. In certain species of *Stenopora*, *Rhombopora* and *Anisotrypa* they are also arranged in a single series, but in these they are confined to a distinct linear space which separated the walls of adjoining zoœcia. Structures of probably the same type, but slightly modified, occur in the walls of *Idiotrypa parasitica* and *Nicholsonella ponderosa*.

The spine-like structures of *Fistulipora utricula* Rominger, *F. spinulifera* Rominger, and other species of the genus, which Nicholson and Foord identified with the "acanthopores" of *Dekayia*, are, most probably, of a very different nature. That in tangential sections they resemble small acanthopores is true, yet certain peculiarities, which they often show in an unmistakable manner, indicate functions decidedly different from those here attributed to the true acanthopores. On plates 46 and 48 I have figured sections of various species of *Fistulipora*, some of which are provided with the structures in question. Upon close examination we find that the cover of the interstitial vesicles is perforated by one or more minute openings that look

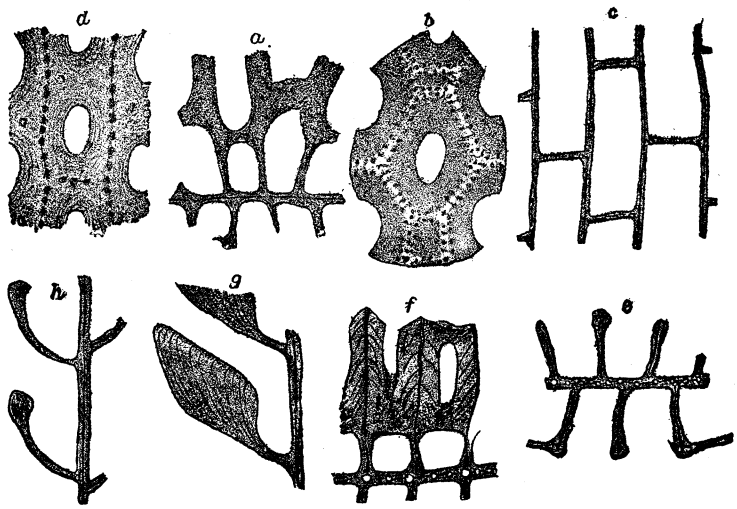

Fig. 2.—a, Transverse section x 50 of *Ptilodictya variabilis*,* showing the basal portion of the two layers of zoœcia, and the duplex character of the median lamina; between the plates there is no series of median tubuli.—*b*, small portion of a tangential section of *Tæniodictya cingulata*, x 50, showing a transverse lining of the central region of the walls, a character often present among the PTILODICTYONIDÆ.—*c*, deep tangential section of *Stictopora mutabilis*, Ul., x 50, showing the primitive portion of the zoœcia and the median tubuli in their walls.—*d*, tangential-section of same showing characters of zoœcia just beneath the superficial aperture.—*e*, transverse section of a young example of same, x 50, showing median tubuli.—*f*, transverse section of old example of same, x 50.—*g*, Vertical section through one zoœcium of an old example of same, x 50.—*h*, vertical section section of a young specimen of same, x 50.

*This name is proposed instead of *Ptilodictya nodosa* for the form figured in my "Amer. Pal. Bryozoa," under that name, Hall's *Escharopora nodosa* (Pal. N. Y. vol. 1, 1847,) having proved to belong to *Ptilodictya*.

just like the supposed acanthopores; and, when the section passes through the zoarium just beneath the surface of a fully matured example, where the vesicles are filled with a dense deposit of sclerenchyma, they cannot be distinguished from each other. Precisely the same conditions prevail in *Coscinium*, *Evactinopora*, *Phyllodictya*, *Pachydictya*, *Idiotrypa*, *Nicholsonella* and *Constellaria*, and, with the addition of true acanthopores, in species of *Trematopora*. On account of their excessive minuteness and consequent liability to obliteration, I have found it extremely difficult, if not impossible, to determine whether these structures are ever actually tubular (i. e., like the acanthopores, passing in a continuous line through successive stages of the zoarium). The evidence afforded by vertical sections is generally opposed to this view, excepting in some sections of *Cystodictya* and other genera, in which the secondary deposit that filled the interstitial vesicles exhibits a finely lined appearance, making it not unlikely that calcification was arrested by the pores and only extended around them, so that with the continuation of the deposit, they gradually formed tubular shafts*. Taking all the evidence at hand into consideration, the only plausible explanation would seem to be that we are dealing with small perforations in the calcareous covers of the mesopores and interstitial vesicles. Whether these were closed at the termination of each stage, or remained open so as to maintain communication throughout the zoarium, is a problem we may never be able to solve.

In species of *Ptilodictya* of the type of *P. pavonia* D'Orb., and *P. falciformis* Nicholson, and *Tæniodictya* (n. gen.) and *Cyclopora fungia* Prout, the intra-mural space is crossed by numerous dark lines, which tangential sections, taken from exceptionally preserved specimens, show to be composed of closely arranged spots. Whether these spots represent extremely minute vertical tubes or moniliform tubuli, which traversed the

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*In the Ann. & Mag. Nat. Hist. 5 ser. vol. 13, p. 213, Rev. T. Hincks, the eminent authority on recent Bryozoa, describes a very similar condition in the development of his *Mucronella spinosissima* var. *major*. After stating that in the young state there are two or three rows of pores around the margin of the zoœcia, he says, "As calcification proceeds it is arrested by the pores and only extends around them and not over them; so that they continue open and form at last tubular shafts piercing the stony crus which has been piled up about them."

walls in a transverse direction, is a point not yet determined. The evidence at hand favors the last possibility more than the first.

Sections of *Rhombopora lepidodendroides*, *R. crassa*, *Bactropora, simplex*, *Stenopora? signata* and several other species, exhibit a most peculiar character, which is perhaps best shown in the species last mentioned. In tangential sections of these forms, the portion af the wall immediately surrounding the zoœcial cavity displays one or two series of minute spots with a dark or lucid central space, while each "acanthopore" is likewise encircled by a row of the same spots, which again in the central region of the walls are arranged is closely approximating clusters of six or more. As viewed in vertical sections, they still present only the appearance of minute spots, and I have not observed anything showing that they communicated either with each other or the zoœcia, nor can I offer any explanation of the singular structures-

In a large proportion (perhaps all) of the FENESTELLIDÆ the non-poriferous side of the branches as well as the spaces between the zoœcia apertures are pierced (?) by very minute vertical tubes, which compare with the surface pores of both the CYCLOSTOMATA and CHEILOSTOMATA.

VI. *Structure of the walls of the zoœcia.*—From a zoological point of view the minute structure of the cell walls is of the first importance. Unfortunately, however, the process of fossilization has so often obliterated the finer details, that great caution and careful examination are necessary if we would obtain a correct idea of their structure. Still, with the aid of good sections the differentiations are determinable and may be utilized with great advantage in the framing of our classification. Before we proceed to discuss the more common modifications in the minute structure of the zoœcial walls, it is necessary to notice a very important feature of zoarial anatomy.

a. "Mature" and "immature" regions. In the TREPOSTOMATA and CRYPTOSTOMATA, namely, the tubular zoœcia which make up the zoarium become more or less modified in their structure as they approach the surface and pass into their final stage of growth. In all cases, whatever their structure may be in the final and most developed condition, they commence with thin and apparently indivisible walls. This I have called the "immature" portion of the tubes; in the ramose, frondescent, and bifoliate forms, it occupies the axial and deeper regions of the zoarium. The peripheral or what I have termed the "mature" region commences near the point at which the tubes bend outward and from there extends to the surface. Generally, the two regions differ widely from each other. Thus in the "immature" region the tube walls are exceedingly thin and the diaphragms, if not entirely absent, are always separated by longer intervals than in the "mature" region, while none of the accessory elements, such as the mesopores and acanthopores, are developed until the zoœcia have passed out of this region. On the other hand, in the "mature" region the walls of the zoœcia become more or less extensively thickened, and if at all present, such structures as the cystiphragms and perforated diaphragms, mesopores and acanthopores are developed. As already mentioned, the diaphragms are also comparatively more numerous and, as I will endeavor to show in the section on diaphragms and opercular structures, in some forms at any rate appear to be of a different nature from those which cross the tubes in the "immature" region. The thickening of the walls of the tubes by a secondary deposit and a general increase in the deposition of calcareous material is one of the most conspicuous features of the "mature" region.

The thin walled basal or prostrate portion of the zoœcia of the bifoliate, encrusting and fenestrate species, is equivalent to the "immature" region of the dendroid forms, while the erect portion represents the "mature" region. Among massive forms the two regions are often readily distinguished. This is especially so when the zoarium is composed of numerous layers as in *Stenopora polymorpha* Prout. In cases of this kind each layer is divisible into a prostrate or immature and an erect or mature region. Less easy is the task with species like *Monotrypa? filiosa* D'Orb., and *Monticulipora mammulata* D'Orb., in which the layers are so intimately connected that the tubes form continuous lines through the mass. Yet even in these, the two zones are distinguishable, the walls being slightly thicker and the diaphragms more closely arranged in the "mature" region than in the immature. I have seen specimens of these species in which it was possible to distinguish more than twenty successive zones, with out a break in the continuity of the tubes. A separation of the zoarium into different zones is apparently not possible with the true species of *Monotrypa* (e. g. *M. undulata* Nich., *M. rectimuralis*). In these extremely simple forms the walls of the tubes remain excessively thin throughout their length, the diaphragms are separated by wide and unequal intervals, and neither mesopores nor acanthopores are present.

b. Independence of the Zoœcia walls.—Theoretically it may be said that the zoœcia of all the Palæozoic Bryozoa had perfectly independent and complete walls. In many cases this independence of the wall of each individual cell or tube is clearly preserved throughout the entire growth of the zoarium and in

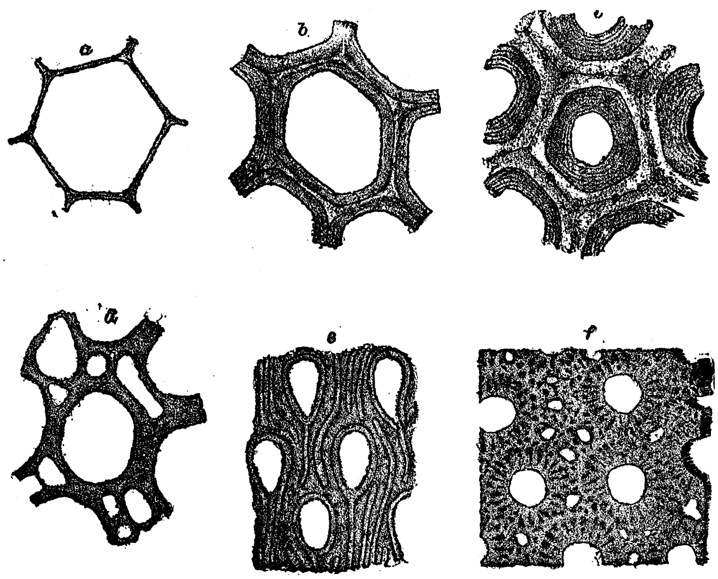

Fig. 3. Tangential sections of Palæozoic Bryozoa showing variations in wall structure, x50. *a. Monotrypa rectimuralis* Ul., showing the extreme simplicity that marks that genus. *b. Monotrypella æqualis* Ul., showing structure of walls just beneath the surface. *c*, a similar section of *Amplexopora cingulata* Ul., showing slightly more complex structure. *d*, similar section of *Callopora subnodosa* Ul., showing apparent amalgamation of walls. *e*, *Arthropora shafferi* Meek, *f*, *Heliotrypa bifolia Ul.*, showing the most complicated structure yet seen.

thin sections of such forms, of which *Monotrypella pulchella* Ed. & H.. *Amplexopora cingulata*, *Anisotrypa symmetrica*, *Stenopora carbonaria* Worthen, *Ptilodictya pavonia* D'Orb., *Nematopora lineata* Billings, *Pachydictya everetti*, *Batostoma variabile* and many others are examples, the visceral chambers of each zoœcium is seen to be surrounded by its own calcareous investment, and to be separated from its immediate neighbors by a more or less clearly marked dark or light line. The actual thickness of the walls inside of the divisional line varies with the species, but in a comparatively small number of forms, represented by the species like *Monotrypa rectimuralis*, *Diplotrypa petropolitana* Pander, and *D. patella*, they are so thin that their duplex character cannot be made out in thin sections, appearing in them merely as delicate dark lines. However, as Nicholson truly says, "rough fractures will demonstrate what thin sections fail to show." In rough fractures of the zoaria of these species the tubes always separate clearly from one another, each carrying with it its own wall, a phenomenon which could not be possible if the primitively duplex condition of the walls of adjoining tubes had in reality been destroyed.

In another group of forms comprising mainly thick walled species, and, with others, the species of *Batostomella*, *Leioclema*, *Atactopora*, many of *Rhombopora* and several of *Stenopora*, there is no distinct divisional line in the centre of the partition between contiguous tubes and the walls appear to be actually

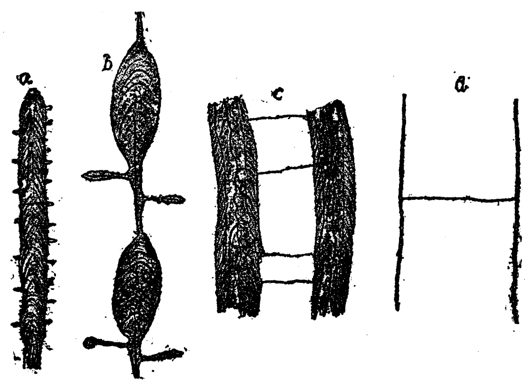

Fig. 4. Vertical sections x50, showing variations in wall structure. *a*, *Monotrypella æqualis* Ul.; *b*, *Stenopora americana* Ul.: *c*, *Amplexopora cingulata* Ul.; *d*, *Monotrypa rectimuralis* Ul.

amalgamated. That there is no real fusion of the walls in these cases is shown by abundant and conclusive evidence, furnished, however, only by exceptionally preserved material. Ordinarily the visceral cavity is surrounded by concentrically laminated sclerenchyma, while the central portion of the partition seems absolutely structureless. After a careful examination of numerous sections, I find that this condition of parts is mainly due to two causes, (1) imperfect preservation, (2) to slight irregularities in the deposition of the internal laminæ of the sclerenchyma. The first cause needs no explanation, as better specimens will show the median line in the wall which we *know to be double.* The second occurs only in forms having the partition rounded at the surface (*e. g. Stenopora carbonaria*, Worthen) and never in those in which they are carinate (*e. g. Anisotrypa symmetrica*). When observed in longitudinal sections, the partitions between the zooecia are seen to be composed of a succession of superimposed conical layers, which are deposited one upon the other as the growing margin of the wall is carried upwards. When the centre of the partition is carinate at the surface, then a more or less distinct straight line passes through the apices of the conical laminæ, but in those forms that have the superficial termination of the partitions rounded, the separating line or primitive wall is often made slightly zigzag by the alternate overlapping of the deposit on each side. This peculiarity sufficiently explains the fact that while the divisional line may be quite distinct at one point of a tangential section, it is scarcely or not at all perceptible in other portions of the section. In considering the wall structure of Bryozoa with numerous "mesopores," like *Callopora*, *Trematopora*, *Constellaria* and *Leioclema*, we find no difficulty in demonstrating the independence of the walls of each zooecium, since, even when in contact with each other, a divisional line is generally traceable. To show the duplex character of the partitions between the mesopores, is a far more difficult task, yet, that they are really double, will scarcely admit of question. Like the thin-walled tubes of *Monotrypa* and *Diplotrypa*, as well as the extremely thin partitions of the tubes in the axial or immature region of nearly all the Palæozoic Bryozoa, the double condition of the mesopore walls is conclusively shown by the fact that fractured surfaces almost invariably exhibit the exterior of the tubes. On the contrary, rough fractures of Bryozoa with interstitial vesicles like *Fistulipora*, *Cystodictya*, etc., expose the interior of the cells. I am, therefore, not inclined to regard these as each having its own complete investment. The only portion of the confining investment which can be said to be strictly its own, is the convex plate which forms its upper boundary.

If actual fusion of the walls of contiguous zoœcia ever occurs among Palæozoic Bryozoa, it is to be looked for in the CERAMOPORIDÆ. This family is distinguished by a wall structure differing obviously from that observed in such Bryozoa as *Leptotrypa*, *Stenopora*, *Rhombopora*, *Amplexopora* or *Batostomella*. In the CERAMOPORIDÆ, namely, the walls of adjoining zoœcia and mesopores seem to be perfectly amalgamated, and, so far as observed, rough fractures always exhibit the interior of the tubes. In species with thick walls (*Diamesopora communis*) the central portion of the partitions, as seen in tangential sections, is sometimes apparently structureless, but generally a more careful examination will reveal a peculiar granular or intermittent appearance, while in species with thin walls (*e. g. Crepipora simulans* and *C. hemisphærica*,) the whole wall is of this composition. Very nearly the same granular wall-structure is observed in species of *Monticulipora*, but in these the duplex character of the partitions is demonstrated by rough fractures. In all these cases the appearance here described as granular or intermittent, is most probably due to the imperfect preservation of excessively minute pores in the walls of the tubes. Being a feature of some importance, it will be referred to again.

The most obvious peculiarity of the Ceramoporoid wall is found in the irregularly laminated deposit immediately surrounding the tube cavity. The lines which separate the concentric laminæ rarely extend around the wall, and in most instances are not parallel. Sometimes they even appear to intertwine. When examined in vertical sections the walls present the appearance of being composed of narrow, super-imposed, alternately light and darker bands of sclerenchyma, which slope backward and downward. A narrow structurless and often nearly colorless band which lines the inner side of the posterior wall, represents the lunarium, which (among the CERAMOPORIDÆ) is usually distinguished from the rest of the zooecial investment by its lighter color.

The primitive duplex character of the zoœcia walls of the FENESTELLIDÆ and ACANTHOCLADIIDÆ is generally shown in deep tangential sections, but, after they have passed into the erect stage, the divisional lines are rapidly obliterated by the deposit of layers of calcareous material in the spaces between the apertures. As is seen in transverse and vertical sections, these layers are deposited equally over all portions of the original zoœcia, appearing as parallel bands, conforming with the shape of the primitive zoarium. Among the bifoliate genera of the CRYPTOSTOMATA, *Stictotrypa* is built up upon very nearly the same plan. Here, also, the originally thin cover of the zoœcium is thickened by the deposition of successive horizontal or concave layers of sclerenchyma. Vertical sections of this genus, therefore, are very different from those of *Stictopora* and *Ptilodictya*, in which the walls are constructed upon the same plan as in *Rhombopora*, etc.

Lastly, the walls of the CYCLOSTOMATA genera *Stomatopora, Protocrisina, Mitoclema*, etc., have that finely granular appearance in thin sections, which I consider as indicative of an originally porous condition of the wall. That the walls were really pierced by fine pores is clearly shown by numerous specimens from Cincinnati, O., and elsewhere. So far as the independence of the walls of contiguous zoœcia is concerned, the sections studied offer no positive evidence.

c. Connecting foramina or communication pores.—While evidence showing that the zooids of a colony communicated freely with each other is abundant, it is nevertheless true that it is rarely or never so conclusive with Palæzoic Bryozoa as to determine this point beyond dispute. Only now and then a specimen is found furnishing any evidence whatever to bear upon the question, and in the great majority of cases the observer is left in total ignorance upon this important point of bryozoan anatomy. Of the most typical CYCLOSTOMATA, some of which were represented in Palæzoic times, we know that the partitions between adjoining zoœcia are perforated by numerous minute pores, and it is of these forms that we may regard the evidence bearing upon the point in question (presented by thin sections), as reasonably conclusive. But if the peculiar granular structure of the walls of these Bryozoa is admitted to be conclusive evidence of their originally porous condition, we must also admit that the walls of *Monticulipora* (restricted) and the CERAMOPORIDÆ were porous as well, since thin sections of those forms exhibit precisely the same granular wall structure. The same also applies to many FISTULIPORIDÆ.

Nicholson and Ethridge jun. claim to have discovered "mural pores" in species of *Stenopora**. Unfortunately for the discovery the very illustrations which these observers give to show these structures, also show in on unmistable manner that the discovery is founded upon faulty observation. Their new species *S. jackii* is said to exhibit the "mural pores" in a more satisfactory manner than any of the others studied by them. Three figures are given, two of them (*b*, *c*) enlargements of *a*, representing a vertically split branch. The explanations to the figures set forth that *b* and *c* show the annulations of the tubes in their outer portions and the mural pores. A knowledge of the minute structure of *Stenopora*, such as we must believe these authors possessed, should immediately have explained certain peculiarities which are presented by the specimen figured. The authors ought furthermore to have seen that the form of the tubes ascribed by them to *S. jackii* is totally different from that of *S. ovata*, Lonsdale, in being brought into contact with each other only at subregular intervals by periodic ring-like swellings, instead of being in contact *throughout their length*. On the other hand, a little more careful examination would, perhaps, have revealed the fact that the interspaces between the supposed tubes correspond exactly with the walls of a Stenoporoid as they appear in vertical sections. The fact of the matter is that these usually so cautious observers were mislead by a peculiar, yet not uncommon state of preservation, consisting, namely, of the dissolving or wearing away of the actual walls of the zoarium, whereby the siliceous or semi-siliceous casts of the interior of the tubes is exposed to view. Specimens of *S. carbonaria* Worthen, from the Coal Measures of Illinois,

*Ann. & Mag. Nat. Hist, 1879, Vol. IV, p. 275.

exhibit the same condition precisely when they have undergone some weathering. With this new light upon the subject, *Stenopora* once again reverts to the imperforate forms, since we have no conclusive evidence showing that any true species of the genus possessed perforate walls.

That some at least of the structures mentioned in the section devoted to "median tubuli" aided in the inter-communication of the zoœcia, I cannot doubt, but nothing comparable to the communication plates of the CHEILOSTOMATA has yet been recognized in their Palæozoic ancestors. As only the "immature" or prostrate region of the zoœcia of *Ptilodictya*, and other genera of that type, is equivalent to the ordinary Cheilostomatous cell, the communication plates, if they existed at all, ought to be found in the thin walls that separate the zoœcia in that region.

VII. *Opercular structures, diaphragms and cystiphragms.*—Opercular structures seem to have been present in most Bryozoa, yet among fossil forms they are of extremely rare occurrence. Among the CHEILOSTOMATA their absence is readily accounted for by the fact that the operculum in these is incapable of preservation, since it is composed of horny substance. In the CRYPTOSTOMATA, which are Palæozoic representatives of the CHEILOSTOMATA, the operculum was most probably also horny. In many cases, however, notably the FENESTELLIDÆ, the secondary or superficial aperture was closed by a thin centrally perforated plate, which, most probably was not developed till at the final period of growth. This seems to be shown by the absence of diaphragms in the tubular orifice beneath it, and the fact that the plate has been observed in fully matured examples only. This plate has also been detected in tangential sections of very old examples in which the zoœcial orifices are covered with a dense layer of sclerenchyma having the same structure as the dense substance of the non-poriferous side of the branches. In these sections the central perforation in the operculear plate is surrounded by numerous minute dark spots, which probably represent former pores. Among the CYCLOSTOMATA the zoœcial tube is similarly closed by a perforated frail calcareous plate situated usually a short distance from the aperture. This plate

I have detected in the tubes of several Palæozoic CYCLOSTOMATA, but unless it is terminal (see pl. XXIV, fig. 2,) the closest search may fail to reveal it.

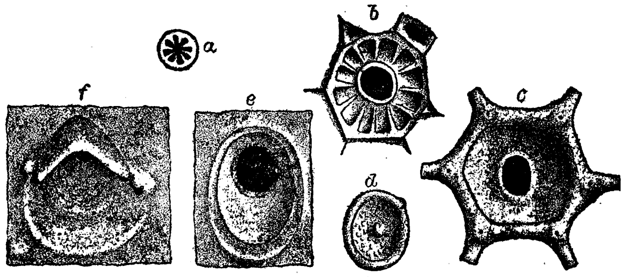

Fig. 5.—Six illustrations showing various forms of opercular covers, x 50. *a*, perfect aperture of *Pinnatopora stellipora* Y. & Y. *b*, perfect aperture of *Callopora ramosa* d'Orb. *c*, aperture of *Stenopora tuberculata* Prout. *d*, aperture of *Polypora biseriata*, having the central perforation of the cover closed. *e*, *Meekopora clausa* Ul.; *f*, *Fistulipora foordi* Ul.

In typical CYSTODICTYONIDÆ and some FISTULIPORIDÆ (*e. g. F. foordi*, Pl. XLVIII, fig. 7,) the larger portion of the aperture is often found closed by a plate. The remaining open portion is of circular outline and occurs immediately within the lunarium. In *Meekopora clausa* (pl. LXXVII, fig. 7,) and other FISTULIPORIDÆ, the perforation in the opercular plate is sub-central. When in a good state of preservation the zoœcial tubes of *Callopora*, *Stenopora* and several species of *Batostomella* are closed by a centrally perforated opercular structure. Ordinarily the perforation is surrounded by a slight rim and the whole plate may be either slightly concave or convex and smooth. In *Callopora elegantula* Hall, *C. ramosa* d'Orb, and other species of the genus, six to ten small ridges radiate from the perforated centre to the margin, giving the false appearance of a septate aperture. These structures, as they occur in the TREPOSTOMATA, are most certainly not developed only at the final period of growth, as some authors have thought, but we have abundant evidence to show that what at one time served the purpose of a cover to the zoœcium, next formed the floor of the succeeding cell; in other words, became a "diaphragm." Furthermore, there appears to be no reason to doubt that this process was carried on throughout the extent of the "mature region" since in tangential sections of these forms the opercula of previous cell-layers are often recognizable. Their recognition is especially easy in *Stenopora,* since in species of that genus the central perforation generally remains open. Occasionally an exceedingly thin membrane is stretched across. In *Callopora* the perforation is closed by a secondary deposit and cannot be detected excepting when it differs in color from the rest of the plate. The calcareous plates which cross the tubes in the immature region of the zoarium in the Bryozoa under consideration, seem to have been without perforations of any kind, but so far as we can determine, they are precisely like the true "diaphragms." The latter are probably the most characteristic feature of the TREPOSTOMATA, occurring, perhaps without any exception, in all the members of this suborder. They consist of simple calcareous plates, flat, or convex, which cross the zoœcial tube at near a right angle. In all cases they occur at shorter intervals in the mature region than in the immature, while in the mesopores the diaphragms are also comparatively more numerous than in the zoœcia. *Idiotrypa parasitica* is an exception to the last rule, since in that species the diaphragms occur upon the same level in all the tubes. In *Dekayia* and *Dekayella,* at certain periods in the growth of the zoarium, a thin pellicle is drawn over greater or smaller patches of the surface, while other portions have the cell-apertures open. This membranaceous covering was doubtlessly developed at the final period in the existence of the zooids of each layer of cells, and after forming the floor of the succeeding layer, ultimately became a diaphragm.

True diaphragms are of very rare occurrence among the Cryptostomata, but in species of *Ptilodictya* Lonsdale (*Heterodictya* Nich.), the larger specimens are composed of more than one layer of cells. Each layer is marked by an inferior and superior hemiseptum (just the same as the original cell) which in vertical sections might be mistaken for diaphragms.

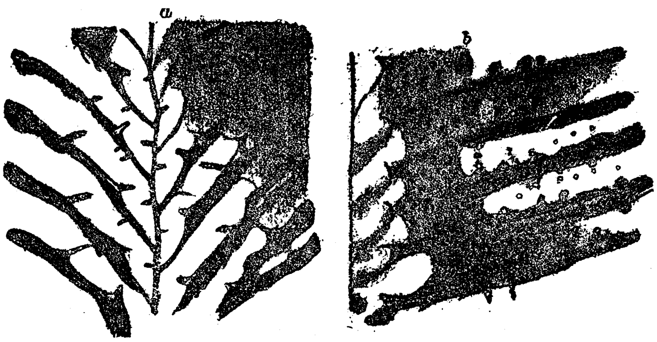

Fig. 6. *a*, vertical section of *Ptilodictya variabilis* Ul., x 35, showing several hemisepta; *b*, half of a slightly oblique vertical section of *Ptilodictya maculata* Ul., showing peculiar hollow spine-like processes projecting into the zoœcial cavity.

Upon careful examination it will be noticed that the supposed diaphragms spring alternately from the two walls, and that they do not extend to the opposite wall but terminate at some point between them.

The peculiar structures which I have called cystiphragms are very characteristic of some of the most typical TREPOSTOMATA. They are best shown by and almost restricted to the MONTICULIPORIDÆ, comprising the genera *Monticulipora*, *Peronopora*, *Prasopora*, *Homotrypa*, *Homotrypella* and *Atactoporella*. When examined in vertical sections of these genera, the cystiphragms are seen to form a series of lenticular vesicles on one (rarely both) sides of the zoœcial chamber. They are usually joined to each other in such a way that they present the appearance of overlapping curved lines. In tangential sections the vesicles are seen to extend around about two-thirds of the circumference of the cell chamber (or sometimes to encircle it) their cut edges giving the appearance of an enclosed eccentric tube within the zooecial cavity. The space between the inner margin of the cystoid series and the opposite wall is intersected by horizontal plates or ordinary diaphragms, which may be as numerous as the cystiphragms. In species of *Prasopora* (e. g. *P. oculata* and *affinis* Foord, and *P. selwyni* Nich.,) the cystoid diaphragms are often isolated so that they do not touch each other at all. In this condition the structures compare very favorably with certain interzoœcial vesicles which I have observed in *Ceriocava ramosa* d'Orb., from the Cretaceous of France.

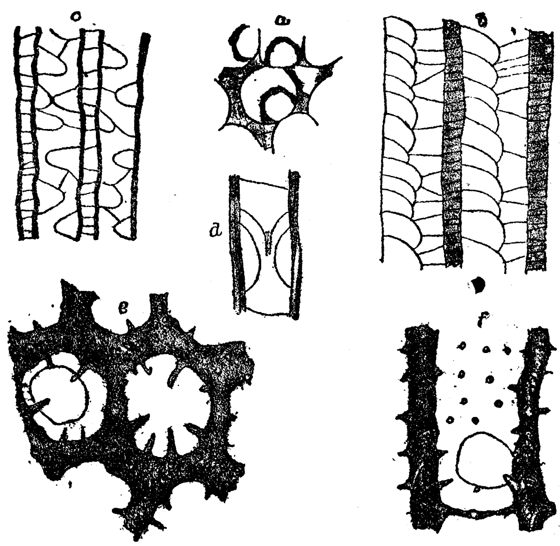

Fig. 7. *a* and *b*, transverse and vertical sections of *Prasopora lycoperdon* Vanuxem, showing the usual type of cystiphragms. *c*, vertical section of *Prasopora affinis* Foord, showing the isolated cystiphragms. *d*, small portion of a zoœcial tube of *Amplexopora robusta* Ul., showing a funnel-shaped diaphragm supposed to be a modified cystiphragm. *e* and *f*, transverse and vertical sections of *Ceriocava ramosa*, d'Orb., showing, beside the spinelets and peculiar wall-structure, two vesicles that are supposed to be homologous with the cystiphragms.

In the accompanying cut I have figured sections of this species for comparison with sections of Silurian forms having cystiphragms. In the Cretaceous form the vesicles are sub-spherical and may be attached to the zoœcial wall, or suspended from the radiating spinelets so as to hang apparently free in the zoœcial chamber. In the first instance they resemble the isolated cystiphragms of *Prasopora affinis* Foord, in a marked manner, and I do not think there can be any question that we are dealing wish structures in every way homologous with true cystiphragms*.

* Since the above was written I have detected very similar structures in an undetermined species of *Fistulipora* from the Hamilton group of New York.

Lastly in *Amplexopora cingulata*, *A. robusta*, and other forms, we have certain structures which may be peculiar modifications of the ordinary cystiphragms. These occur in the tubes near the surface of the zoarium. In vertical sections of these species (fig. 7d) the first or innermost appears as two convex lines which spring out from each wall and extend about one-third of the diameter of the zoœcium into its cavity. Above these another pair of convex lines run parallel with the outer half of the first pair, and after approaching each other quite closely form a tubular prolongation, which extends some distance down into the space between the first pair. In tangential sections they appear in the zoœcial cavity as too circular lines, of which the larger one encloses the smaller. From these appearances, it is clear that the first was of hour-glass shape, and the second funnel-shaped.

At the present time I am not prepared to offer a satisfactory explanation of the cystiphragms. I may be permitted, however, to suggest that they were in some way connected with the reproductive functions.

VIII. *Lunarium.*—This important character, with slight modifications, is found in the CERAMOPORIDÆ, CYSTODICTYONIDÆ and most of the FISTULIPORIDÆ. In its typical and most common form it is a more or less nearly semicircular portion of the posterior half of the zoœcial walls. The ends of the semicircle or crescent project into the zoœcial chamber to a variable degree, depending upon the comparative length of the radii, being greatest when the radius of the semicircle is shortest.

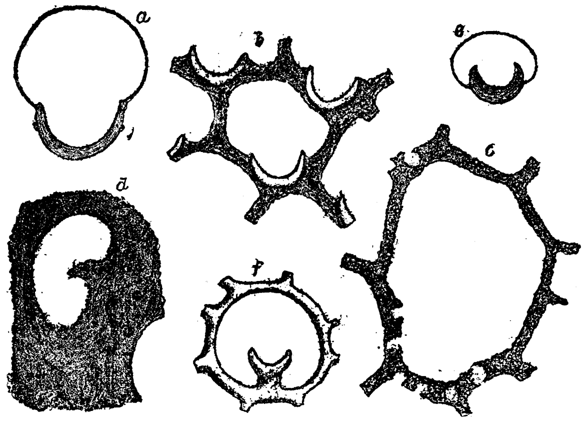

Fig. 8. Six illustrations showing modifications of the lunarium. *a. Fistulipora astrica* Ul.; *b, Crepipora simulans* Ul.; *c, Anoloteichia ponderosa* Ul.; *d, Cystodictya occellata* Ul., one of the zoœcia divided horizontally just above the primitive orifice; *e*, vestibule of a coœcium of *Cystodictya gilberti* Meek, cut transversely just beneath the external aperture; *f*, zoœcium aperture of *Buskopora.*

In the above cut, *a*, representing a tangential section of a zoœcium of *Fistulipora astrica* Ul., shows the lunarium in its normal form; *b*, shows the true "crescent" as it appears in *Crepipora* and other Ceramoporids. Here the outer or convex line of the crescent is sharply defined, the inner much fainter, and the intermediate space filled with nearly transparent structureless substance; *c*, is apparently intermittent, or traversed in a longitudinal direction by minute tubuli, which vertical sections (pl. XLI, fig. 3c,) show to have been intersected by numerous diaphragms- *d*, represents a zoœcium of *Cystodictya* just about to pass in the mature stage; *e*, the cell just beneath the external orifice. These show that the lunarium is not developed excepting in the vestibular portion of the zoœcium. In *Buskopora* (fig. *f.*) we see a decided modification. In this remarkable genus the lunarium is formed by the channeling of an internal ridge which projects far into the zoœcial chamber. In *Cystodictya gilberti* Meek, and *Coscinium cribriformi* Prout, (Pl. XLIII, fig. 7, 8) the crescent is also very prominent (especially near the edge of the zoarium) but it is a much less separate structure.

IX. *Wall inflections.*—Nothing that will compare with the "septa" of a coral, nor even the imperfect spiniform septa of so many of the FAVOSITIDÆ has yet been detected in any bryozoan. In a number of forms, however, there are indentations of the wall which a superficial observer might mistake for such structures. In most cases these inflections are produced by the developement of "acanthopores" in the walls of the zoœcia. They are well shown in *Atactopora*, *Atactoporella*, *Amplexopora septosa*, *Batostoma implicatum* Nich., and *Heterotrypa inflecta*. In a few other cases of which *Actinotrypa peculiaris* Rominger (Pl. LXXVII, fig. 3, 3a, 3b) and *Glyptopora keyserlingi* Prout, may be mentioned, there are vertical ridges on the inner side of the walls, which are not produced by acanthopores. In *A. peculiaris* these ridges terminate at the surface as spine-like projections on the peristome of the cell. Their number, though varying from six to ten, is usually eight or nine. When examined in tangential sections they are found to be best developed near the surface, and that, as the section cuts the zoarium at a deeper level, they gradually become more and more obtuse till they are no longer recognizable, the cell aperture having at the same time been traced to its primitive circular form. In *Glyptopora keyserlingi* the inflections are both less numerous and less defined, as well as much more irregular. Ordinarily two of them occupy positions in the wall opposite to the lunarium.

In the species of *Ptilodictya* (especially the section of the genus typified by *P. pavonia* D'Orb., and *P. maculata*) I have often observed certain tooth-like processes which project from the walls into the interior of the visceral chamber. In large examples of *P. maculata* and *P. hili*, they are often very numerous, several tangential sections of the first species now before me exhibiting from two to four in each cell. I have also recognized them in vertical sections of this species, (see fig. 6b) but here they sometimes look so much like perforations in the wall that I originally described them as such.* Perhaps it is not now possible to give a satisfactory explanation of these singular projections, still a comparison with several recent Bryozoa may give us a clue to their nature. In the first place we find that the spine-like projections are developed at correspond-

* Am. Pal. Bry. Jour. Cin. Soc. Nat. Hist. vol. V, p. 163, 1882.

ing levels in contiguous tubes. This brings us to a point which ought never to be lost sight of in the study of Palæozoic Bryozoa. Namely, that in the TREPOSTOMATA and many CRYPTOSTOMATA, the tubular zoœcium really represents a series of superimposed cells. This fact is very well shown in fig. 6a representing a vertical section of *P. variabilis*. Upon examination, it is clear that each tube in this section contained two successive zoœcial chambers, each of which was provided with its own superior and inferior hemiseptum. In *P. pavonia* and *P. maculata* the last structures are repeated at much shorter intervals, but on account of their extreme delicacy are rarely preserved. Returning to the consideration of the spine-like projections, I find that they resemble the radiating spines which occur in the tubes of several species of *Heteropora* and *Ceriocava ramulosa*, D'Orb. In these also the spines are developed at corresponding levels in contiguous tubes. Next I would suggest a comparison with the spines which project from the walls and over the cells in a number of recent species of *Membranipora* (e. g. *M. spinifera* Johnston, *M. lineata* Linn. (Hincks.)

CHAPTER II.

CLASSIFICATION AND INTERRELATIONS OF FAMILIES AND GENERA.

As this work deals solely with Palæozoic Bryozoa it is quite unnecessary to enter into the various systems of classification that have been proposed for the arrangement of Secondary, Tertiary, and recent representatives of the class, excepting in a general way, and more in detail when these classifications included some of the Palæozoic types.

D'Orbigny's elaborate classification shows a knowledge of bryozoan form that stands unrivaled even to-day. His lucid descriptions and excellent plates reveal a wonderful variety of structure and an almost endless array of beautiful forms. How very unfortunate then that a work so laudible should be accompanied by an extremely artificial classification, and a nomenclature so complex that it is bewildering.

D'Orbigny's first attempt at a systematic arrangement is found in his "Cours elementaire de Palæontologie," which was shortly followed by a more comprehensive synopsis of the fossil forms in the "Prodrome de Palæontologie." Lastly in the "Palæontologie Francaise, vol. V" he publishes his completed classification, embracing all the forms known up to 1852, making in all two hundred and nineteen genera and one thousand nine hundred and twenty-nine species. Upon this vast array of bryozoan diversity he based a wonderfully artificial system, which has been abandoned, perhaps without an exception, by all subsequent authors who have made a special study of Bryozoa. His two grand divisions, the BRYOZOAIRES CELLULINÉS and BRYOZOAIRES CENTRIFUGINÉS correspond very nearly with Busks CHEILOSTOMATA and CYCLOSTOMATA, and to him, therefore, belongs the credit of being the first to delineate the two principal divisions of the GYMNOLÆMATA. His family and generic groups, on the other hand, have little to recommend them, as they are largely based upon the most trivial characters, such as the presence or absence, position and number of the "special pores," complete and incomplete calcification of the anterior wall, while even individual peculiarities or conditions due to age are credited with generic importance. As, however, d'Orbigny is the only author who has sought to account for the entire field of fossil and recent Bryozoa, the palæontologist has been obliged, in the absence of a more natural system, to accept that of this emminent French naturalist as an indispensible basis.

With a single exception (*Hippothoa inflata* Hall,) all the Palæozoic species known to d'Orbigny, were placed by him in his order CENTRIFUGINÉS (CYCLOSTOMATA Busk). None of them, however, really belong there, though true Cyclostomatous Bryozoa were not uncommon in some of the Palæozoic rocks. As instances of the unnatural collocations often found in his system I may mention *Omniretepora* (generally supposed to be a synonom for *Fenestrella*) *Archimedipora* (*Archimedes* Leseur), the Fenestellid genera *Fenestrella*, *Fenestrellina*, *Reteporina* and *Polypora* McCoy, and the ACANTHOCLADIIDÆ *Keratophytes* Schlotheim (*Acanthocladia* King), *Penniretepora*, *Ptylopora* McCoy, and *Ichthyorachis* McCoy. The first is found among the CRESCISIDÆ with *Heteropora* and genera of that type, the second with the TUBIGERIDÆ, and all the rest among the SPARSIDÆ where they are total strangers.

Busk's skillfully devised system* has rendered most important service in promoting the study of fossil and recent Bryozoa. For D'Orbigny's CELLULINÉS he proposed the appropriate name CHEILOSTOMATA, and this division especially, he sought to divide into natural families and genera, taking the zoarial characters, or in other words, the result of the mode of combination of the zoœcia, as of the first importance. With such characters as a basis he succeeds in dividing the class into convenient and readily recognized groups, which are particularly adapted for

* "British Museum Catalogue, 3 pts.," "Crag Polyzoa," Palæontographical Soc. Pub."

the easy identification of species. In this respect the system is not surpassed by any other, but being very largely an artificial arrangement, it too often gives the student no clue to the natural relations of his species, which after all must be the first aim of classification. For this reason, therefore, however well adapted to the wants of the collector, the system can hold only a provisional place. In his last works† Mr. Busk has modified his system to a considerable extent, so that it now seems much more in accordance with nature than formerly. Still, while I am not ready to admit that zoœcial characters alone, should be consulted in the framing of a system of classification, I am, nevertheless, convinced that even now Mr. Busk credits zoarial variations with more importance than they deserve. Palæozoic Bryozoa have received very little attention from this eminent authority, and beyond placing some of the well known genera into his suborder CYCLOSTOMATA, he does not account for them.

Hincks, whose work applies almost exclusively to recent representatives of the class, follows and greatly enlarges the system first proposed by the Swedish naturalist, Prof. F. A. Smitt. The latter aims at a genealogical classification, starting with the supposition that the variations of species follow the line of their development, and may be in a great measure explained by it. In accordance with this theory he would arrange the Bryozoa in series according to the law of their evolution. This doubtlessly opens a most interesting and important field for inquiry, one that I believe deserves more attention than it has yet received. Still in the present stage of our knowledge, the morphology of the class will be better advanced by recognizing and clearly discriminating between the more constant variations than by uniting them upon grounds, which only in rare instances can be unquestionable, into comprehensive specific groups under a single name. If a genealogical arrangement in detail is ever possible, it will only be after we have taken into account every departure from the simple and more permanent types. Hincks himself thinks that Smitt's arrangement of the Bryozoa in genealogical groups is premature, and his reduction of species excessive, as well as often confusing, because unwarranted.

† Challenger Reports.

After the feature of Prof. Smitt's work just noted, the next important is the value he assigns to the zoœcium in the formation of families and genera, the zoarial characters being on the other hand treated as perfectly subordinate. His claim is that the cells themselves, and not the mode in which they combine, furnish the true test of relationship, and the essential basis of a natural classification.

As Busk's three orders of the GYMNOLÆMATA are founded upon structural peculiarities of the cell, they are accepted by both Smitt and Hinck's. When however it comes to the farther divisions of the order into families and genera, we find that the new system departs very widely from the classifications of Busk and d'Orbigny. As none of their families are represented in Palæozoic Rocks, it is not necessary, at this time, to follow the system in greater detail.

Unfortunately, none of the supporters of the new classification have in any way sought to account for the Palæozoic types, so here we find a perfectly free and unoccupied field. With respect to these the first question that arises is, which system or classification gives the best results, that in which the zoarial characters are assigned a high degree of importance, or the other in which the zoœcium alone furnishes the test of relationship. If it was necessary to make an absolute choice between the two systems, I would not hesitate very long before accepting the second, for it can not be questioned that differentiations in the cell or actual home of the polypide are more trustworthy structural variations than the form of the zoarium. Still, since the latter in a large measure must be due to deviations in cell structure, it follows that zoarial as well as zoœcial peculiarities should be taken into account in the framing of a classification, and while it also follows that in their relative values, the former must necessarily be subordinate to the latter, we should not overlook the individuality of the zoarium as a continuous whole or entity, since we do not fully understand the comparative significance of zoarial and zoœcial characters.

An extended study of Palæozoic Bryozoa shows me that in classifying these early types much caution must be exercised, and that no character or set of characters has the same classificatory value throughout when applied to a large number of forms. The value of a character must be determined by its constancy and degree of prevalence, and experience will show that the value is not by any means the same when observed in different groups of species. Thus a character may be sufficiently constant in one set of forms to be considered of generic importance, while in other species the same peculiarity may be found so variable that its value is almost over estimated, when we call it specific. As an instance of this variability in the significance of a character I may mention the two "mesopores" which are constantly present between the ends of the cells of *Phænopora*, Hall. In other respects this genus is almost identical with *Ptilodictya* Lonsdale. In this case, therefore, the position and number of the "mesopores" is a generic character. In *Stictoporella* and *Intrapora* Hall, precisely the same kind of "mesopores" are constantly present, but as they vary in number and position (even in the same species) their arrangement in these cases is only of specific value.

This naturally suggests the question, when are we justified in considering a variation as having generic, specific or only varietal importance? In the first place, the answer depends very much upon the views held by the individual who is to make the divisions. Some authors make genera and species upon a very small margin, while others give their divisions undue latitude. My own plan is simple enough, and so far as I can see, fills all the requirements of classification, as the result is a system that is convenient as well as natural. Convenience is a necessity, and, in the framing of a classification, must be taken into consideration just as much as the natural relations of the organisms we seek to arrange. These two necessary features of a permanent classification I have sought to furnish in the system here proposed. With what success will be determined by future research. That it will be lacking in many points of minor detail I do not doubt, yet, taken as a whole, I feel convinced that it will meet with favor. Some of the older palæontologists will doubtlessly object to what they consider my excessive multiplication of species and genera. The same complaint will come from other naturalists who are endowed with more than ordinary ability in solving genealogical problems. The first class of dissenters belong to the old school of naturalists, the second are extremists of the new. Opposed to these is the steady growth of a tendency to provide for all the recognizable stages in the development or evolution of organic nature.* Perhaps the principal cause for this tendency is found in the fact that now, more than ever before, naturalists confine themselves to the study of special groups, and it is well known that specialists, at any rate modern ones, make species and genera upon small provocation. Their great familiarity with the minor details of structure may perhaps magnify the points of difference, but, on the other hand, we must not forget that this same familiarity gives them an insight into the relative values of structural variations which the ordinary student cannot possess. As good illustrations I have but to mention the admirable system recently proposed by Zittel for the classification of the Sponges, Haeckel's work on the RADIOLARIA, and Wachsmuth and Springer's excellent work on the PALÆOCRINOIDEA. Some of the older authors too, who have kept pace with the remarkable progress of natural history, and have adopted modern methods of investigations, offer striking instances of the "tendency." Take for instance Hall's recent works on Devonian Fossils, Barrande's last, and De'Koninck's magnificent contributions to the Carboniferous fauna of Belgium. Even more striking in this respect is Davidson's supplementary work on British Brachiopoda. He was, perhaps, the

* Every classification must, to a certain extent, be artificial and arbitrary, since it is impossible to draw up a system that will follow out all the intricacies of evolutional existence. Again, the "vanishing lines" of nature forbid our looking for sharply defined groups or species, consequently our divisions are necessarily more or less arbitrary. In practice, species gradate almost insensibly by means of intermediate species and varieties into each other, while the same instability of characters gradually effaces the separating lines between genera and groups of higher rank. Some authors upon finding the intermediate links between closely allied species are not content with the knowledge thereby gained, but make use of it by reducing the "excessive" number of species. I take a different standpoint, and would like to see every recognizable stage in the evolution of organic beings distinguished from the next by its own name. Now, whether this stage is ranked as a variety or species, is a matter of very little moment to me, since in most cases, the palæontologist at any rate, finds it almost a hopeless task to define just what constitutes a variety and what ought to be called a species. My idea of a genus is a more or less arbitrary group of species, having intimate natural relations to each other. In other words, a greater or less number of species having certain structural peculiarities in common. Sub-genera I hold are a useless encumbrance of nomenclature, as there is very little, if any, need for intermediate divisions between species and genera. So far as I can see they only serve to destroy the uniformity of classification in giving an undue rank and latitude to the genera to which they belong. In many cases these subdivided genera may be said to assume the rank of families.

most conservative of all palæontological specialists, yet in the last five years of his life he established more new genera than during the preceding thirty years. With such illustrious precedents, I feel justified in presenting the following classification of Palæozoic Bryozoa, subject to the decision of future workers in the field.

In making my divisions I have sought to follow nature as nearly as possible, starting with the propositions, (1) that the classificatory value of a character is determined by its constancy, (2) that in the aggregate of characters is found the true test of relationship. From the first proposition it follows that the constant characters, whether zoarial or zoœcial are the significant ones, that their relative values are according to the degree of constancy, the degree being determined only by a comparative study of numerous individuals, species or genera, as the case may be. By experience we learn that modifications of certain features are generally more significant than of others. Thus among th CHEILOSTOMATA the variations of the apertures, the degree in which the primitive opening is preserved or obliterated, and the modifications in the form of the orifice are very important. In the CYCLOSTOMATA, however, the zoœcium is extremely simple and uniform, so that here the systematist must depend almost entirely upon variations in the mode of combination of the cells. When we come to the TREPOSTOMATA, both the zoœcium and zoarium supply us with important characters. The same may be said of the CRYPTOSTOMATA, but among these, perhaps as much as with the CYCLOSTOMATA, must we take zoarial variations into consideration in making generic and family divisions. In a general sense this sub-order may be regarded as representing the *Escharina* group of the CHEILOSTOMATA, but the characters which serve so well in classifying the recent forms are almost always obliterated by subsequent deposits of calcareous material. Thin sections, of course,

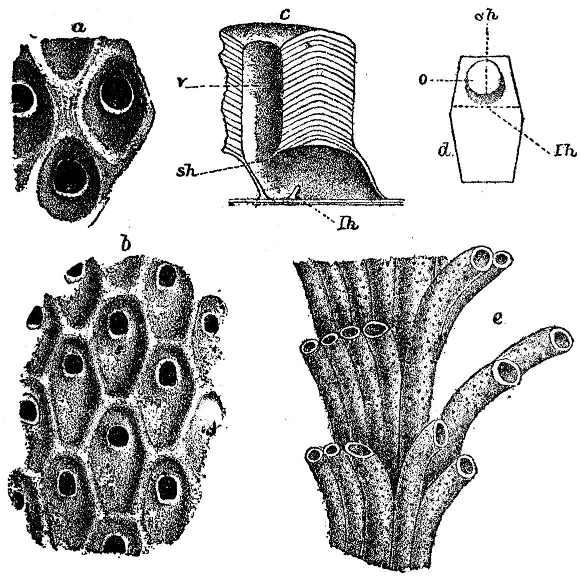

Fig. 9. *a*, *Eschara artemis*, d'Orb. *b*, *E. argyrias*, d'Orb., from the Cretaceous of France (after d'Orbiguy). *c*, diagrammatic vertical section of a Cryptostomatous zoœcium showing the "vestibule" at *v*, the superior hemiseptum at *sh*, and the inferior hemiseptum at *ih*. *d*, outline of the primitive portion of a Cryptostomatous zoœcium, showing the primitive orifice at *o*, the superior hemiseptum at *sh*, and the line of the inferior hemiseptum at *ih*. *e*, Small portion of zoarium of a typical Cyclostomatous bryozoan, (*Idmonea serpens* Linn., after Hincks).

give us an approximate idea of the primitive cell and aperture, but as these features are often of quite uniform construction, we must look to other characters for generic points. These are supplied by the superficial orifice, the presence or absence of mesopores, acanthopores, median tubuli and hemisepta, and by modifications in the form of the zoarium, which, as I have already indicated, are very constant in this sub-order. The bilaminar zoarium is very persistent and, perhaps, the most typical, but the fenestrated forms are more numerous as well as exceedingly constant in their zoarial peculiarities. This is fortunate, since the small, yet readily recognized variations in the construction of the zoarium, supply us with excellent points upon which to found our genera. On the other hand the individual zoœcia of the fenestrated forms, excepting *Phylloporina*, are so uniform that no recognizable peculiarities can be said to distinguish those of one genus from those of another. (Compare sections of fenestrate genera figured on pl. 54 and 56). Taking this uniformity into consideration it seems evident that the Silurian species which I have united under the genus *Phylloporina*, are sufficiently distinguished from the FENESTELLIDÆ to rank as a separate family. Indeed, the tubular zoœcia, which are occasionally intersected by diaphragms, suggest a decided affinity with the TREPOSTOMATA and CYCLOSTOMATA. Granting this relationship, we must not lose sight of the fact that a tubular primitive cell is also characteristic of many of the ARTHROSTYLIDÆ, and all of the RHABDOMESONTIDÆ as well as occasionally in other families of the sub-order (*e. g. Stictoporella* and *Phyllodictya*). It also appears highly probable that in *Phylloporina* we see the ancestors of the more highly developed FENESTELLIDÆ. A comparative study of that family brings to light some important facts. Thus the earliest of the species really belonging to the restricted genus *Fenestella*, differ from the typical Devonian and Carboniferous species in having the thin walled primitive cell more inclined to be tubular; or perhaps it would be better to say, that the anterior and posterior walls are less nearly vertical than we find them in later representatives of the genus. On plate 54, fig. 2, represents a deep tangential section of a branch of *F. bellistriata* (?) Hall, from the Niagara shales at Waldon, Ind. This should be compared with 1*b* on same plate, representing a similar section of *Phylloporina* ? *dawsoni*, from the Trenton group at Montreal, Canada,* and it will be seen that they have one peculiarity in common which is not possessed by the Devonian and Carboniferous species represented by figures 3, 4, 5. Namely, the partitions

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PHYLLOPORINA DAWSONI, n. sp. Branches lax, very slender, 0.3 to 0.5 m.m. wide, irregularly inosculating, often united by non-poriferous dissepiments. Fenestrules acutely elliptical, usually wider than the branches and from 1.5 to 3.0 m.m. long. Reverse convex, smooth or faintly striate. Poriferous side with a sharply angular mesial ridge and one range of cells on each side. Zoœcia sub-tubular, with rather prominent sub-circular apertures, 0.18 m.m. in diameter, five or six in 2 m.m. Tangential sections show a number of minute accessory pores in the interspaces between the apertures.

The reverse of this species very much resembles that of *P. reticulata*, Hall, from the same formation, but sections of the two forms cannot be confounded. Hall's species has three ranges of zoœcia and generally has smaller fenestrules.

Quite abundant in the Trenton strata at Montreal, Canada, and Chimney Point, Vermont. Specimens were received from Sir Wm. Dawson and Prof. H. M. Seely.

between the ends of the cells are directed obliquely upward and outward from the mesial line, instead of at a right angle. *P.* ? *dawsoni*, agrees also with *Fenestella* in having only two series of cells separated by a mesial carina, and the branches united by non-poriferous dissepiments. Taking all these characters into consideration, I think we are justified in regarding *P.* ? *dawsoni* as one of the ancestral types of *Fenestella*. On the other hand, the rather prominent and but slightly contracted cell-orifice point to a relationship with the Cyclostomatous genus *Protocrisina*, sections of which are figured on plate 53.

A careful study into the minute structure of the various species of *Phylloporina* almost forces the conviction upon us that, at some time before the commencement of the Trenton epoch, there existed Bryozoa which combined characters that during subsequent ages became separately specialized and characteristic of widely different groups. Take for instance *P. trentonensis* Nicholson sp. Sections of this remarkable form remind us very strongly of typical Trepostomata, the angular cells, their long "immature" region, and the closely tabulated mesopores, all being present in species of that suborder. The resemblance is heightened in vertical sections of *P. corticosa*, by the addition of diaphragms in the tubular zoœcia. The last species has also a very prominent mesial carina running along the centre of the branches very much as in *Semicoscinium*. The relationship thereby suggested is, however, in no wise born out by further comparison.

In *P. aspera* Hall, *P. reticulata* Hall, *P. dawsoni* n. sp. and *P. asperato-striata* H., the zoœcial tubes are shorter, approaching the Cryptostomatous cell. In the last species the interstitial spaces are occupied by angular mesopores which have been filled by secondary deposits of sclerenchyma. In *Drymotrypa dichotoma* n. sp. we have a species in which the zoœcial structure is not unlike *Phylloporina*, but the branches bifurcate frequently and are not united by anastomosis as in that genus. The general aspect, therefore, is not at all unlike that of a small species of *Thamniscus*. That genus, however, has the short cells characteristic of the Fenestellidæ and never has diaphragms. There are some points also which suggest comparison with *Protocrisina*.

The theory which is suggested in the foregoing paragraph is corroborated by similar comparisons between early Palæozoic and more recent representatives of perhaps every class of the Invertebrata. It is well shown in the Mollusca and is especially apparent in those classes that are largely represented in recent seas. The student of Palæozoic fossils is continually beset with obstacles in his endeavor to classify his species, finding over and over again that the rules which serve so well arrange recent material, do not apply to the Palæozoic faunas. To this is attributable much of the confusion which pertains to palæozoology, since, according as the student emphasizes one or the other character, the fossil is removed from one family to another. Is there no remedy for this deplorable state of affairs? The remedy will be at hand when palæontologists generally will have come to realize the vastness of their science, and the importance of accurate and discriminative observation of the minute details of structure. This is the pressing necessity, a minute inquiry into the morphology of Palœozoic life, and the inevitable result,—a better idea of Palæozoic geneaology,—cannot fail to produce harmony where we now have utter confusion. A superficial observer determines the affinities of a fossil very quickly; not so the careful student. He has learned to esteem caution, because he sees how very easy it is to misinterpret a character, and how extremely difficult the task of correlating the ancient types with the living. A full appreciation of this difficulty may have led me to propose and adopt divisions that workers on recent Bryozoa may object to in the beginning. Thus the suborder CRYPTOSTOMATA lately proposed by Mr. Vine, includes forms which there can be little doubt are to be regarded as the ancestral types of a large proportion of the CHEILOSTOMATA. In fact, the CRYPTOSTOMATA really represented that suborder in Palæozoic times, and we might with with much propriety unite the two groups. Still, as all the Palæozoic forms have certain peculiarities in common in which they differ from the true CHEILOSTOMATA, the better course, at any rate now, is to keep them separate.

The order GYMNOLÆMATA includes, so far as known, all the fossil Bryozoa. The bulk of those in the Palæozoic rocks I have arranged under three suborders: CYCLOSTOMATA, TREPOSTOMATA and CRYPTOSTOMATA, while the CTENOSTOMATA and CHEILOSTOMATA also seem to have had a meagre representation.

I. *Ctenostomata.*—These Bryozoa as they are known in the recent state, are characterized by a horny or membranous test, on which account it is generally supposed that they have not been capable of preservation by fossilization. One of their leading characteristics is the curious opercular mechanism of the zoœcium. The upper portion of the cell wall is thinner than the rest, and terminates above in a number of delicate setæ held together by a thin transparent membrane. When the polypide retreats the whole of this anterior portion is drawn in, and the setæ, being brought close together, form an operculum-like covering above the tentacles. The zoarium is often creeping, with the flask-shaped zoœcia arranged in single series resembling *Hippothoa* and *Stomatopora.* Frequently the zoœcia stand erect upon a cylindrical stem, while in other cases they are immersed.

As already stated the horny membranous test is strongly against finding fossil remains of CTENOSTOMATA, still there are two Palæozoic genera that agree so nearly in habit with certain recent members of the suborder that I can not do otherwise than place them together. These genera are *Ascodictyon* Nich. and Eth. jr., and *Rhopalonaria.** The genus *Ascodictyon* was established by the authors cited for the reception of certain problematic fossils which occur usually as radially arranged, extremely delicate fibres on shells, etc. The fibres vary in length and are sometimes bulbous or inflated at intervals. In a few cases, too, the fossil consists of small clusters of bulbous vesicles which are arranged in a radial manner. When more than one cluster is preserved they seem to be connected to each other by a thread-like fibre. The substance of the fossil appears to be corneo-calcareous. *Ascodictyon* may be compared with species of *Valkeria*, *Bowerbankia* and *Cylindrœcium*, as figured by Hincks (British Marine Polyzoa). The Silurian genus *Rhopalonaria* imitates *Hippothoa* in its zoarial habit. The zoœcia are

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* Since the above was written I have learned that in the Ann. & Mag. of Nat. Hist. for Aug., 1884, Mr. Vine in discussing these two genera, suggests a comparison with the stoloniferous VESICULARIDÆ (CTENOSTOMATA).

slender spindle-shaped, united to each other by their extremely attenuated terminations, or by an uninflated filiform tube. The substance of the zoarium is very thin, dark brown or black, and only rarely preserved, but on account of its curious habit of excavating the substance of the body upon which it grew, the form of the zoarium, as well as that of the zoœcia is generally clearly defined and recognizable. The orifice is small, indistinct, and readily overlooked in the best specimens at hand. *Rhopalonaria* compares favorably with species of *Arachnidium* Hincks; *A. clavatum* Hincks (*loc. cit.* pl. 71, figs. 3,4,5) is especially recommended.

The species of *Ascodictyon* and *Rhopalonaria* should perhaps be placed in distinct families, but, as it is not probable that either one of the genera belongs to any of the recent families, and as our opportunities for comparison between fossil forms of the suborder are necessarily very limited and unsatisfactory, I regard it sufficient for present needs to arrange the Palæozoic species in one family, the ASCODICTYONIDÆ.

II. *Cyclostomata.*—The forms of this suborder are characterized throughout by simplicity of structure, the zoœcia being always tubular, with the mouths simple, rounded, inoperculate, and generally exert; the walls thin, of nearly uniform thickness throughout, and minutely perforate; all appendicular organs are wanting. The polypide also is more than usually simple in structure, has comparatively a small number of tentacles, while the larvæ of the principal families are almost identical. It is really a very difficult matter to divide this suborder into satisfactory families and genera. On account of the extreme simplicity and uniformity of the zooecium, we must depend almost entirely upon variations in zoarial habit and mode of zoœcial aggregations. These are generally striking, and among Palæozoic forms at any rate, usually reliably indicative of true relationship. Thus, while in *Mitoclema* the zoœcial tubes are long and radiate equally in all directions to open on all sides of a cylindrical stem, they are shorter, beaded proximally, and those opening on each side of the compressed branches, are separated by an axial plane in *Diploclema*. *Protocrisina* again differs from both in having one side of the branches without cell apertures.

True CYCLOSTOMATA appear already in the Chazy horizon of the Lower Silurian, from which the author has described *Mitoclema cinctosum.* This species, though probably belonging to the same family as *Entalophora* Lamx., differs from species of that genus in several important particulars*. The axial region of vertical sections is more like what we find among ramose TREPOSTOMATA or CRYPTOSTOMATA.

In the Trenton proper we find already a fair representation, the following genera having been determined: *Stomatopora* Bronn, *Berenicea* Lamx., *Scenellopora, Protocrisina, Diploclema* and *Phacelopora,* each with one or two species. Individuals of these forms are rather uncommon, but with the beginning of the Cincinnati group both species and individuals become more abundant. *Scenellopora* is not yet known from these rocks, but another group of species nearly related to *Stomatopora,* and apparently congeneric with the species for which Audouin proposed the genus *Proboscina,* now make their appearance. In Upper Silurian deposits I have detected only *Berenicea* (*Sagenella* Hall) two species, *Stomatopora,* one, *Diploclema* one or perhaps two. For Devonian forms that may belong here, Hall proposes several genera, but no true CYCLOSTOMATA are as yet known from the Carboniferous rocks. Thus it seems that the suborder was better represented during Silurian times than at any subsequent time before the beginning of the Jurassic deposits. Several interesting facts are brought out by a comparison of these ancient types with their much more numerous Mesozoic relatives.

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*In a paper on Australian Bryozoa, Mr. A. W. Waters not only thinks *Mitoclema* the same as *Entalophora,* but he identifies the Chazy form with *E. verticillata* Goldfuss, a Cretaceous species. Mr. G. R. Vine (Rep't on Rec't. Poly.), however, thinks the species distinct and only the genera synonymous. These gentlemen arrived at their hasty and erroneous conclusions without examining specimens, and as the internal structure of *Mitoclema cinctosum* had not yet been made public, they should have deferred their condemnation. When I proposed *Mitoclema* I was acquainted with over twenty species of *Entalophora* (*Spiropora*). All of these possessed one peculiarity which I could not find in my species, namely, all the zoœcial tubes of *Entalophora* originate along the axial line of the branch, and gradually increase in diameter as they curve outward toward the surface. An end view of the branch shows the very characteristic arrangement of the tubes in intersecting curved radial lines. As I have said, this peculiar arrangement is not present in the Silurian species, and I consider myself justified in proposing a new generic name for it.

Species of *Stomatopora* and the closely allied divisions *Proboscina* and *Berenicea* from Cincinnati, Ohio, differ in no appreciable manner from Jurassic and Cretaceous species, while *Mitoclema*, *Diploclema*, *Protocrisina* and *Scenellopora*, closely resemble *Entalophora*, *Bidiastopora*, *Crisina*, and *Defrancia*, respectively. Of all the Silurian forms the two species of *Phacelopora* are probably the most distinct, yet, even these admit of comparison with some of the TUBULIPORIDÆ.

The large size of most of the Devonian forms makes it somewhat doubtful that they are really Bryozoa, still their general aspect is so much like that of typical CYCLOSTOMATA that I do not see how they can be placed elsewhere. To determine the question beyond dispute requires a more minute study than I have found time to give them.

III. TREPOSTOMATA:—The zoaria of this suborder are composed of prismatic or cylindrical tubes, that change more or less in character as they pass from the "immature" into the "mature" region. In the "immature" region the tubes have extremely thin, prismatic and simple walls, while horizontal diaphragms may or may not be developed here. The "immature" region of a zoœcial tube is longer in the ramose forms, than in the lamellar and parasitic, and is equivalent to the primitive cell of the CHILOSTOMATA and CRYPTOSTOMATA. The transition from the "immature" to the "mature" condition is often gradual, but more generally rather abrupt, though never so much so as in the CRYPTOSTOMATA. The change consists of (1) a thickening of the walls, (2) the development of mesopores, and (3) an increase in the number of diaphragms. Opercular structures and perforated diaphragms also only occur in the mature region. Each stage in this region marked by the diaphragms, represents a layer of zoœcia, each of the individual chambers having been developed in direct sequence from the zoœcium immediately beneath it. By repeating the process a tabulated tube resulted.

This suborder, though having living representatives, attained its greatest development during Palæozoic times. In Mesozoic and more recent times the distinctive characters are largely subdivided, and, by equal concessions on the part of the CYCLOSTOMATA, the dividing line between the divisions has become somewhat shadowy and certainly much less sharp than we find it to have been during the early periods of their existence. So little is known of the internal structure of Mesozoic CYCLOSTOMATA and TREPOSTOMATA that it is not now possible to distinguish satisfactorily between them. It would be presumptive on my part to attempt it. In a general way, however, it may be said that the Mesozoic types which are provided with mesopores, such as the majority of the genera referred by d'Orbigny to his families, CLAUSIDÆ, CAVEIDÆ, CAVIDÆ and CRESCISIDÆ, are not true CYCLOSTOMATA but rather TREPOSTOMATA.

The Palæozoic genera I have grouped under the nine families, MONTICULIPORIDÆ, HETEROTRYPIDÆ, CALLOPORIDÆ, TREMATOPORIDÆ, BATOSTOMELLIDÆ, AMPLEXOPORIDÆ, DIPLOTRYPIDÆ, CERAMOPORIDÆ, and FISTULIPORIDÆ. The first may be considered as the most typical, as the forms which constitute the family contain all the more characteristic features of the sub-order.

(1) MONTICULIPORIDÆ:—The zoarium in this group comprising the genera *Monticulipora*, *Peronopora*, *Atactoporella*, *Prasopora*, *Homotrypa* and *Homotrypella*, may be massive, discoid, lamellar or incrusting, while the bifoliate and ramose forms are also frequent. The zoœcia are prismatic, rounded, or irregularly petaloid, with comparatively thin walls, having a peculiar granular structure. The mesopores vary greatly in number, being sometimes apparently absent or very few, at other times very numerous. Occasionally they are obscured by a secondary deposit of sclerenchyma. Zoœcia with cystiphragms, the mesopores with horizontal diaphragms. The acanthopores are nearly always small, and generally numerous.

The family as above restricted contains a large number of mainly Lower Silurian Bryozoa, whose principal character, the cystiphragms, has, so far, proved an almost infallible distinguishing mark. In the genus *Monticulipora* (*e. g. M. lamellosa* and *M. winchelli*) these structures are often modified so that they might be mistaken for simple, oblique or slightly curved diaphragms. Experience, however, will soon dispel the illusion. The genera of the family are separated from each other mainly bý constant zoarial peculiarities, though each also has its own distinguishing zoœcial features.

(2) HETEROTRYPIDÆ:—The zoarium in this family is frondescent, ramose or incrusting. Usually the zoœcia are polygonal, more or less contiguous, with comparatively thin walls. In other cases rounded or oval. The mesopores, though always present, vary greatly in number, being exceedingly few in some cases (*Dekayia*), and quite numerous in others (species of *Dekayella*.) Acanthopores are always present, sometimes being of very large size (*Dekayia*). Generally they are small and placed at the angles of junction between the zoœcia. Their cavity, too, is usually very small, but in species of *Batostoma* it is larger than in any other member of the TREPOSTOMATA. No cystiphragms are present, and the diaphragms are always horizontal and conspicuously more numerous in the mesopores than in the zoœcial tubes. Another peculiarity frequently met with, especially in species of the typical genera of the family, is the closing of the cell apertures on limited or extended portions of the surface by a thin, apparently imperforate calcareous pellicle.

The four genera, *Heterotrypa* Nicholson, *Dekayia* Ed. & H., *Dekayella*, and *Petigopora* constitute the family as here understood. These genera clearly have natural affinities, differing from each other only in the number of mesopores, thickness of zoœcial walls, and in the form of the zoarium. Thus *Heterotrypa* is characterized by moderately thick-walled zoœcia, comparatively few mesopores, and a frondescent or compressed habit of growth; *Dekayia* by its thin walled zoœcia, a ramose or subramose zoarium, and by the practical absence of mesopores; *Dekayella* by the numerous mesopores, and two sizes of acanthopores; and *Petigopora* by the parasitic habit of growth and non-celluliferous epithecal margin.

(3) CALLOPORIDÆ:—The zoarium in this family may be dendroid, subfrondescent, discoid, or, rarely, sub-pyriform. The zoœcia are sometimes polygonal, but usually sub-circular, and separated from each other by numerous angular mesopores, which, when the zoœcia are rounded, more or less completely isolate them. Zoœcial walls generally thin, rarely thickened and ring-like in transverse section. Cystiphragms are wanting,

while small acanthopores are only occasionally present. The apertures of the zoœcia are closed by centrally perforated plain or radially striated opercula.

This family is proposed provisionally for the reception of the three genera *Callopora* Hall, (restricted, Ulrich), *Calloporella*, and *Aspidopora*, which have the above noted peculiarities in common. The opercular covering of the zoœcial aperture is considered the principal distinguishing feature. The genera are separated by easily recognized characters, *Callopora* having a ramose zoarium, thin walled, polygonal or sub-circular zoœcia, a varying number of mesopores, and no acanthopores. The last structures are developed in moderate numbers in both *Calloporella* and *Aspidopora*, the zoarium in both again being discoidal and free, with a concentrically marked epithecal membrane on the concave under side. The first is distinguished from the second by having thick ring-like walls to the zoœcia and different mesopores.

(4) TREMATOPORIDÆ:—Ramose, irregularly frondescent, or parasitic zoaria pertain to forms of this family. The zoœcial tubes are thin-walled, adjoining and prismatic in the "immature" region, subcylindrical or more or less completely isolated by abundant angular mesopores in the "mature" region. The zoœcia apertures are circular, oval, or petaloid, with a more or less distinct peristome, while the mesopores are closed at the surface by numerously perforated closures, the perforations appearing as small hollow spines or granules. Both sets of tubes are intersected by horizontal diaphragms, but acanthopores are often wanting. Neither cystiphragms nor opercula have been observed in any of the species.

The family comprises a number of peculiar and several very beautiful Bryozoa, that suggest affinities, more strongly than any other Palæozoic genera, with Mesozoic types of the TREPOSTOMATA. Thus *Trematopora* compares well with *Heteropora* and other genera of that type, while *Constellaria* and *Stellipora*, closely resemble d'Orbigny's genera *Multicava*, *Domopora* and *Radiopora*.

The family includes besides the three genera already mentioned also the new genus *Nicholsonella*, *Idiotrypa*, and most probably *Dittopora* of Dybowski. The last is little known, and I have not met with any species having the characters ascribed to the genus by its author. The others are distinguished by easily recognized structural peculiarities and corresponding zoarial features. *Leioclema*, now referred with some doubt to the next family, may prove to have closer affinities with *Trematopora* than I am at present disposed to admit.

(5) BATOSTOMELLIDÆ. The zoaria of this family vary exceedingly in shape, but are never bifoliate. The ramose habit of growth pertains to a majority of the species. In the "mature" region the zoœcia have thick walls, usually appearing here as though fused together. Here too the diaphragms are centrally perforated, having originally functioned as covers to the zoœcia apertures. Specimens preserving the opercular covers are rare, and it is only in some of the Carboniferous forms that the perforations are invariably shown by good thin sections of the peripheral or mature region. Mesopores are usually present and sometimes abundant, but they are often intermittent, and generally without distinct walls and diaphragms. Acanthopores well developed. Intramural dots are also shown in tangential sections of most species.

The six genera *Batostomella*, *Stenopora* Lonsdale, *Anisotrypa*, *Bythopora* Miller and Dyer, *Callotrypa* Hall, and *Leioclema* almost seem an incongruous assemblage, yet after a very careful comparison, I do not see how they are to be kept separate. Being intermediate in its construction, *Batostomella*, is selected as the type of the family, From that genus we can trace easy gradations into *Callotrypa*, through *Bythopora*. On the other hand *Batostomella nitida*, from the Chester group, is not at all far removed from good species of *Stenopora*, while again it is easy to show a very decided affinity between *Stenopora* and *Anisotrypa*. On account of the diverse structure of the different genera comprised in the family, I have found much difficulty in grasping the really significant characters of the group, and I am not certain that they are all mentioned in the above brief definition. Still I believe our present requirements are satisfied.

Comparing the BATOSTOMELLIDÆ with other families, I find, first, that the Lower Silurian species of *Batostomella* are related to *Homotrypa* of the MONTICULIPORIDÆ; second, several species of *Stenopora* to the AMPLEXOPORIDÆ; and, third, several other species of *Stenopora* and *Anisotrypa* to the RHABDOMESONTIDÆ of Vine. The last comparison, if complete and thorough, establishes a close chain of connecting links between the TREPOSTOMATA and CYRPTOSTOMATA.

(6) AMPLEXOPORIDÆ.—The zoarium in this group, comprising the genera *Amplexopora*, *Monotrypella*, *Petalotrypa*, *Leptotrypa*, *Atactopora* and *Discotrypa*, may be ramose, bifoliate, encrusting, massive or discoidal. The zoœcial characters are more simple than in any other family of the suborder, the colony being composed of subequal, usually thin-walled, prismatic tubes, crossed by variously disposed horizontal diaphragms. The divisional line between adjoining zoœcia is generally distinctly marked, and in a few cases, (e. g. *Monotrypella crassimuralis*) the zoœcia become rounded near surface, leaving triangular tabulated interspaces, that closely simulate mesopores in vertical sections. True mesopores are, however, wanting, but small abortive cells, usually filled internally by a calcareous deposit, sometimes occur among the zoœcia forming the monticules. Acanthopores are absent in *Discotrypa*, but in the other genera they are more or less abundant and sometimes conspicuous.

On account of the simplicity of construction, we are forced to depend very largely upon zoarial variations in dividing the family into generic groups, Of microscopic characters the presence or absence of acanthopores is of the first importance in distinguishing the genera.

(7) DIPLOTRYPIDÆ. This family is proposed provisionally for the reception of *Diplotrypa*, *Batostóma* and *Monotrypa*, three genera that have given me no little trouble to place satisfactorily. Though fully persuaded that their association in one family is natural, I am still not prepared to discuss their inter-relations and affinities with other Bryozoa.

(8) CERAMOPORIDÆ. In the typical genera of this family the zoaria form thin parasitic expansions, but other modes of

growth are frequent. Thus, in *Crepipora*, lamellate, discoidal, and massive species occur, while a ramose zoarium characterizes species of *Diamesopora*. The bifoliate and frondescent styles of growth are also met with. The zoœcia usually form short tubes, but in *Crepipora*, *Anolotichia* and *Chiloporella*, they are much longer and occasionally traversed by a small number of diaphragms. A complete peristome sometimes surrounds their apertures, but in most cases, only the posterior margin projects. The lunarium, which is situated on this side, is nearly always easily recognized, being of a decidedly lighter color in sections than the rest of the zoœcial investment. The irregularly laminated construction of the walls, which appear also to have been minutely porous, is the most striking, as well as, the most constant character. The irregularity of the mesopores and the absence of diphragms in them are other features that aid in distinguishing this peculiar family of Silurian Bryozoa.

The affinities of the family are clearly with the FISTULIPORIDÆ, and the superficial resemblance between, for instance, *Ceramoporella* and *Eridopora* is very marked, yet the internal characters above mentioned are so constant and distinctive that they demand recognition.

(9) FISTULIPORIDÆ.—In this large and important family the zoarium varies greatly, but the massive and laminar with a rugosely wrinkled epitheca on the under side, are the commonest forms. Bifoliate and ramose species are less frequently met with. The zoœcia too vary considerably in the form of the aperture, but in a majority of cases it is sub-oval, or sub-triangular. In other cases the sub-pyriform or circular aperture may prevail. Usually the apertures appear oblique, the degree of obliquity being largely governed by the relative prominence of the lunarium or hood. When they appear direct, the lunarium is as a rule obsolete. Diaphragms are rarely numerous being in most cases almost absent. In the perfect and mature condition the interspaces always seem solid at the surface and frequently granulose. Thin sections, however, show that the zoœcia are always separated from each other by from one to three rows of vesicular cells, which, near the surface of mature examples, are nearly or quite filled by a deposit of vertically

lined calcareous material. The vesicles generally decrease in height outward, and, at least partially, already separated the zoœcia at their origin. True acanthopores and cystiphragms never or only rarely occur, but certain peculiar spines of *Lichenotrypa cavernosa* Nich, very much resemble the first. It also appears that in the perfect state the zoœcia apertures are covered by eccentrically perforated closures, and the perforation itself seems at last to have been closed by a knob-like stopper.

In all, ten Palæozoic genera are included in this family, two of them, *Pinacotrypa* Ulrich, and *Botryllopora* Nich., with some doubt. As the student will perceive by referring to the sub-joined synopsis of classification, each genus is distinguished from the other by certain zoœcial as well as zoarial peculiarities.

A monographical study of the FISTULIPORIDÆ is very much needed, and till the numerous and diverse forms of this exceedingly difficult family have been subjected to a thorough investigation, it will be utterly impossible to arrive at any satisfactory conclusion with regard to the limits and really distinctive peculiarities of the several generic groups now regarded as comprising the family.

IV. CRYPTOSTOMATA:*—In the typical section of this sub-order the zoarium is bifoliate, consisting of two thin layers of zoœcia that have grown together back to back into ramose or foliar expansions. In other groups the zoaria form fenestrated expansions, consisting of only a single layer of cells, the reverse being covered by a dense layer of striated or minutely granulose

*This suborder was proposed in 1883, by M. G. R. Vine, in his 4th report to the Brit. Assoc. on fossil Polyzoa. His *Ptilodictya lonsdalei*, which seems to belong to *Phænopora* Hall, rather than to *Ptilodictya* of Lonsdale, is regarded as the type of the sub-order, but his idea of the true relation and the extent of the proposed division must have been vague, for he places here only the five genera *Ptilodictya*, *Arcanopora* (*Cystodictya*), *Glauconome* (Vine, *non* auct.), *Stictoporella* and *Rhabdomeson*, while the FENESTELLIDÆ and ACANTHOCLADIIDÆ and other allied Bryozoa are left with the *Cyclostomata*. In "Notes of Joredale Polyzoa of North Lancashire," 1885, he increases the list of genera to nine by the addition of *Rhombopora* Meek, *Hyphasmopora* R. Ethridge jun., *Streblotrypa* Ulrich, and *Goniocladia* R. Eth. jr. In my "Am. Pal. Bry.," I placed the PTILODICTYONIDÆ as the first family of the TREPOSTOMATA, immediately following the FENESTELLIDÆ, ACANTHOCLADIIDÆ and ARTHROSTYLIDÆ (ARTHRONEMIDÆ) which were arranged at the end of the CYCLOSTOMATA. Now, recognizing Mr. Vine's suborder, those three families and the PTILODICTYONIDÆ and STICTOPORIDÆ, as there arranged, go to form the bulk of the CRYPTOSTOMATA as here understood.

sclerenchyma. In the remaining sections the zoaria are ramose, with the zoœcia arising from a real or imaginary axis and opening on all sides of the cylindrical stems. Usually the zoaria are continuous; but in some of the bifoliate and ramose forms they are composed of a greater or smaller number of segments. The variations in the form of the primitive cell suggest a rough division of the suborder into three sections. In the first, containing only the CYSTODICTYONIDÆ, the cell is semi-cordate or obovate-acuminate in outline; in the second, comprising the PTILODICTYONIDÆ, STICTOPORIDÆ, FENESTELLIDÆ and ACANTHOCLADIIDÆ, it is oblong quadrate, hexagonal or rhomboidal; the third section, to which the PHYLLOPORINIDÆ, ARTHROSTYLIDÆ and RHABDOMESONTIDÆ belong, is distinguished by the tubular form of the primary cell. In this respect several members of the third section make a close approach to the TREPOSTOMATA.

All positive evidence goes to show that the primitive cell of the CRYPTOSTOMATA corresponds to the entire zoœcium of the ordinary CHILOSTOMATA. The only ground upon which the new suborder can be distinguished from Busk's well established division is the production of the primary orifice into a tubular shaft ("vestibule"). Whether this will be regarded as a sufficient reason for the separation of these Bryozoa into two equal divisions, may be well questioned, since several genera now classed with the CHILOSTOMATA (e. g. *Steganopora* and *Disteganopora* of d'Orbigny, and *Steganoporella* of Smitt) exhibit practically the same peculiarity. Provisionally at least, it seems desirable to hold them as distinct, because the feature pertains to such a large number of Palæozoic Bryozoa, which have received through it a decidedly different aspect from that expected of CHILOSTOMATA. The fact that the peculiarity is so rare in secondary and more recent ages, in which the true CHILOSTOMATA are so abundant, also argues strongly in favor of the separation by allowing us to assume that such genera as *Steganopora* are only the remnants of an extinct Palæozoic type of structure.

In a large proportion of the CRYPTOSTOMATA the primitive aperture is marked by the development of an incomplete plate which extends downward and forward from the posterior side of the base of the vestibule into the primitive or true cell. This

I have termed the superior hemiseptum. The inferior hemiseptum is less frequently met with. When present it springs from the bottom of the cell or from near the base of the anterior wall. The disposition of parts will be better understood by referring to the diagrammatic section of the cryptostomatous cell given in fig. 9(p. 330); see also fig. 10 (p. 351), and, on plate LV, figures 7 and 8: The vestibule is the cylindrical portion of the cavity that is included between the external aperture and the superior hemiseptum. The latter is best developed in forms having a sloping area around the external orifice, yet, even among these, (*e. g. Stictoporella*, fig. 13,) it may be quite obsolete or entirely unrecognizable. When the external aperture is surrounded by a peristome the superior hemiseptum is nearly always wanting, but the inferior may be present.

The material which I propose to arrange under this suborder is divided into eleven families, comprising together seventy or more genera,—some of them very prolific. The PTILODICTYONIDÆ may be regarded as the most typical.

(1) CYSTODICTYONIDÆ:—In this family the zoaria are composed of two or three layers of cells, that grew together back to back, forming by their union either bifoliate expansions or triangular branches, the particular zoarial habit assumed by the various genera being very constant. The margins are non-poriferous and finely granulo-striate, while the zoœcial apertures over the basal portions become gradually covered by the same kind of calcareous depôsit. The form of the primitive cell is probably the most distinctive feature of the family, being semi-cordate or obovate-acuminate in outline, both forms being found in the same example. They are always arranged in longitudinal series, between vertical plates, usually alternating and, either entirely separated from each other, or in contact at only limited portions of their circumference, the intermediate spaces being occupied by vesicles. The primitive orifice was terminal, of sub-circular form and somewhat eccentric, while the front of the cell was slightly convex, and appears to have been minutely punctured (fig. 8,*d*). As growth proceeded the orifice was drawn out into a tubular vestibule, and the spaces between the apertures, keeping pace with the development, were filled by vesicular tissue. Just below the surface of mature examples this tissue was itself more or less completely filled by a calcareous

deposit. Here the vertical plates between which the primitive cells are arranged are also obsolete, although they may still be represented at the surface by ridge-like elevations. A complete peristome usually surrounds the superficial aperture, but sometimes the lunarial side only is elevated. A peculiar feature about the lunarium is that it is always directed away from the non-poriferous margins.

In internal structure and zoœcial characters the various forms of this family show great uniformity, so that we are forced to rely almost solely upon zoarial peculiarities in drawing the generic divisions. Fortunately these are very constant, and, being conspicuous, readily serve the purpose of classification.

The affinities of the family are with the FISTULIPORIDÆ on the one hand and the STICTOPORIDÆ on the other. *Pachydictya* has all the characters of the CYSTODICTYONIDÆ, excepting the lunarium, and it seems highly probable that they had a common origin. The FISTULIPORIDÆ, however, approach closest in their later representatives (e. g. *Meekopora*), a fact apparently indicating that the agreement is due to the moulding influences of surrounding conditions rather than to ancestral relationship.*

(2) STICTOPORIDÆ:—The bifoliate zoaria of this important family formed compressed, dichotomously dividing, continuous or segmented branches, or palmate or leaf-like expansions. The primitive cell is subquadrate, and with or without superior hemiseptum. The inferior hemiseptum and mesopores are apparently always absent, but vesicular tissue is sometimes present. The median tubuli between the divisional laminæ are probably to be regarded as the most important peculiarity of the family, though their true nature and functions have not yet been determined satisfactorily. Likewise the granular terminations of the vertical tubuli, (which I believe to have communicated with those between the median laminæ and to have formed part of a system of communication between the primary cells and the external surface,) are more or less conspicu-

* Many instances might be mentioned to show that like surroundings are apt to produce similar variations in really widely different organisms. For instance, in the Cincinnati group at Delafield, Wis., where monticuliferous TREPOSTOMATA prevail, several species occur that are represented by nearly smooth forms in the Ohio exposures of the same formation. At the Ohio localities the mammulated forms are comparatively less abundant.

ous features of tangential sections, and, when the same is sufficiently well preserved, of the surface. The superficial aperture is sometimes circular, but usually of a broad elliptical form, and surrounded by a narrow sloping area, wanting in Pachydictyæ, where it is replaced by a faint peristome.

The family as now restricted comprises the following six genera: *Stictopora* Hall, *Eurydictya*, *Dicranopora*, *Pachydictya*, *Phyllodictya* and *Euspilopora* Ulrich. The first three are distinguished by zoarial differences, the remainder by slight zoœcial modifications as well. I find that *Pachydictya* approaches the CYSTODICTYONIDÆ in having vesicular tissue, the anterior end of the primitive cell sometimes rounded, and a slight peristome around the superficial aperture. Opposed to these points of resemblance is the absence of the lunarium, the presence of median tubuli, and the fact that the prevailing form of the primitive cell is often either sub-quadrate or hexagonal. The chain of evidence showing the relation of the genus to *Stictopora** and *Eurydictya* is completely established through the intermediate species *Pachydictya splendens* and *P. firma* Compared with the PTILODICTYONIDÆ we find a general agreement in the arrangement of parts, but a closer examination will reveal important differences. Of these the absence of median tubuli among the genera of that family, alone need be mentioned here.

(3) PTILODICTYONIDÆ:—Bifoliate zoaria, continuous or jointed, forming leaf-like expansions or compressed branching stems; thus having the same range of zoarial characters as the CYSTODICTYONIDÆ and STICTOPORIDÆ. The outline of the primitive cell is oblong hexagonal or quadrate, or rhomboidal. In the typical genera both the inferior and superior hemisepta are well developed, but in other divisions either one or both are apparently wanting. In old examples of *Ptilodictya* they may be represented at successive levels, so as to simulate diaphragms (see fig. 6 and 11). Vestibular portion of zoœcia with thick walls, the central region between the cavities being usually also of conspicuously lighter or darker color than the rest. In typical forms this region is transversely lined and margined on each

*Regarding *Stictopora fenestrata* as the type of the genus. If, however, *S. elegantula* is insisted upon as the type, then the reader will please read *Rhinidictya* Ulrich, where I have written *Stictopora* Hall.

side by two close rows of exceedingly minute dots (see fig. 2*b*). Untabulated mesopores occur frequently, but in no case known, vesicular tissue. The following genera are placed here: *Ptilodictya* Lonsdale, *Clathropora* Hall, *Tæniodictya*, *Phænopora* Hall, *Ptilotrypa*, *Graptodictya*, *Arthropora*, *Stictoporella*, *Intrapora* Hall, and *Stictotrypa*. Of these, the first, second and third are distinguished mainly upon constant zoarial peculiarities; the fourth has two mesopores occupying the transverse space between the ends of the zoœcia apertures; the fifth, very oblique apertures and a small accessory cell in front; the sixth and seventh have a filiform peristome and vermicular striæ on the interspaces; the eighth has more or less numerous mesopores, very thick-walled tubular zoœcia, with dilating apertures, and no hemisepta; the ninth also has numerous mesopores, but thinner walled zoœcia, with quite an abrupt aperture and an inferior hemiseptum; the tenth has a decided peristome. The systematic position of the last (*Stictotrypa*) is somewhat doubtful.

(4) Fenestellidæ:—This very characteristic Palæozoic group of Bryozoa presents us with an almost endless array of beautiful forms, whose delicate net-work generally affords us proof of the exceeding constancy with which, what may appear to the uninitiated as very trivial zoarial features, recur in species after species. The exceeding abundance of specific modification causes a continual effacement of sharp divisional lines, and I know of no group better calculated to show that such do not occur in nature. On the contrary, the more our investigations are extended, the more evident it becomes that our classifications are necessarily largely based upon arbitrary divisions. Obviously then, that classification is the best which offers the most convenient and at the same time the most natural (genealogical) arrangement possible, a desire not by any means easily realized. In my subdivision of the family I have been guided by the test, that the value of a character is determined by its degree of prevalence. Accordingly, when I have found a number of species that agreed in one or more features without disagreement in others known to have greater importance, I have regarded them as entitled to recognition as a separate genus. Subgeneric divisions, being both inconvenient and useless, I am opposed to, and have not adopted them excepting in such cases where they seem to merit generic distinction.

With the single exception of *Thamniscus*, in which the branches are usually free, the zoaria of this family form reticulated expansions of which only one side is celluliferous, the other being finely granulo-striate. Commonly, the branches are more or less rigid and united to each other by solid processes, which are developed at such regular intervals that their number in a given space affords a good test in the discrimination of species. In other cases the branches are sinuous and united by anastomosis. The fenestrules vary from circular to acutely elliptical, but when the dissepiments are thin, a quadrate form prevails. The primitive cell, or true home of the polyp, is either oblong quadrate or hexagonal, or rhomboidal, and never commences, as claimed by Waagen and Pichl, (Pal. Indica, ser. XIII, Salt Range Foss. p. 772) "in a long thin point." On the contrary, in all cases when the cell is not of rhombic form, the proximal end is truncated, being, furthermore, vertically parallel with the anterior wall. As seen in longitudinal sections, the cell is directed more or less obliquely upward and forward, the angle of divergence from the basal plate varying between the extremes of 45° and 90°. Generally the height of the cell is considerably less than its length, yet in a few instances the two dimensions are almost equal. The inferior hemiseptum is often present, and springs (apparently always) from the anterior wall near its base. Sometimes it is so strong that in deep tangential sections (Pl. LV, fig. 7) the cell appears as though divided into two apartments.

Another peculiarity that may be seen in a tangential section of almost any Fenestellid (see figures on Pl. LIV and LV), is due to the presence of a superior hemiseptum. Namely, at opposite points on the sides of a cell through which the sect on passes, just beneath the level of the primary orifice, the wall is more or less sharply bent in, the inflections being in some cases sufficiently extended to unite, so as to separate an anterior subcircular space from the remaining posterior portion of the cell. Generally, however, the inflection appears strongest on the upper side (especially in *Fenestella*) giving to the cell a rather marked kidney-form outline (see Pl. LI, fig. 5a, and Pl. LIV, fig. 5). This appearance is not due to a greater development of the internal ridge on the outer side, but to the obliquity with which the tangential section necessarily passes through the somewhat laterally directed cells. This is shown in *Polypora*, where the inflections on each side are about equal in the central row or rows of cells, while in those of the marginal rows, which are directed laterally, they appear unequal as in *Fenestella* and other genera having only two ranges of zoœcia (see Pl. LV. fig. 4). The superior hemiseptum, to which these inflections are due, forms a ridge-like thickening on the inner side of the cell, which becomes obsolete, or nearly so, toward the center of the posterior side of the primary aperture, and entirely so at about the middle of the vertical sides, being strongest in the region of the angle, formed by the union of the lateral walls and the slightly convex front or top of the cell. The accompanying digrams will probably serve better to show the peculiarities in question than any verbal explanation.

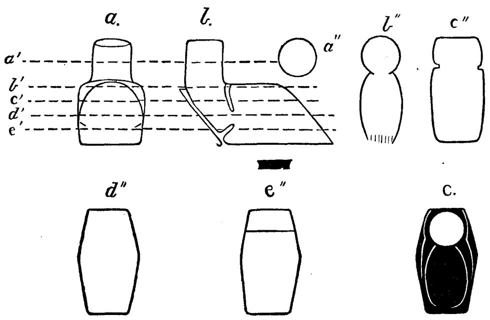

Fig. 10. Diagrams illustrating the different appearances presented in thin sections by the zoœcium of a Fenestellid having both hemisepta. *a* and *b*, side and end sectional views of the zoœcium crossed by five dotted lines, a, b, c, d and e. Drawings a'', b'', c'', d'' and e'' represent the zoœcial cavity as it appears in tangential sections at levels corresponding to the dotted lines. *c*, represents a "nest" of the outlines.

This peculiar feature (whose functions unless it acted as a support to the cell front, is unknown) was noticed in 1878 by Mr. A. W. Waters and described and figured by him in the transactions of the Manchester Geol. Soc. for that year, also by Mr. John Young who, in the Trans. Geol. Soc. of Glasgow for 1879, gives a short description of it. The former found two identations but the latter failed to notice that the apparent inflection on the one side of the cell of species of *Fenestella* is caused by the slight lateral direction of these walls in such form.*

* In this connection it seems proper to show how imperfect observations of certain defective specimens have led the Messrs. Young and Young into an error, which appears not only to have been overlooked by Mr. Vine, but induced him to propose a new family for the sub-generic division proposed by those authors. In 1875 they published a

The primary orifice is of sub-circular form, somewhat narrower than the width of the cell, and occupies the anterior third (or a little more) of its length. As growth proceeded the front of the cell was gradually thickened by a deposit of laminated sclerenchyma; this calcareous addition being built up about the orifice so as to draw it out into a vertical tubular shaft, called the "vestibule" by Mr. Vine. The superficial aperture is circular, and, with few exceptions, surrounded by a peristome.

In transverse sections of the branches the original basal or germinal plate is generally quite distinct from the subsequently added layers of calcareous tissue. A number are figured on plates LIV and LV, that show how sharply the plate is often distinguished. Almost invariably the lower side of the plate presents a number of tooth-like projections that represent transverse sections of former longitudinal striations. It is a fact that the reverse of many Fenestellids show strong striæ on very young examples, which are wanting or nearly obsolete on old specimens.

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description and figures of *Glauconome marginalis*, for which they proposed the new subgenus *Diplopora*, upon the ground that there is a small secondary pore immediately beneath the true apertu:e. Similar secondary pores they mentioned as occurring in their *Glauconome* (*Acanthopora*) *stellipora* and *Fenestella* (*Actinostoma*) *fenestrata*. This secondary pore I consider the result of attrition combined with a paucity of calcareous secretion by the zooids. The Messrs. Young and Young show in their figure of the first that the supposed pore varies much in size, and rightly attribute the variation to the state of preservation. Had they investigated a little farther, I think they would have seen that there is a good reason for the presence of the "pore" in their species. These (especially *D. marginalis*) are forms in which the deposit of cal·areous material over the primitive cell was much less than usual. *Polypora whitei* and var. *sevillensis* are likewise such forms, and, as will be seen from fig. 1b and 2 on plate LXII, frequently present what Waters suggests might be compared with the suboral pore found in so many CHILOSTOMATA. I am really sorry that I find it so often necessary to differ with my esteemed English collaborers in this difficult branch of palæozoology. Indeed, in this instance I am particularly grieved, since it would have pleased me much to be able to corroborate so important a point for comparison between Palæozoic and Recent Bryozoa. But, being convinced that their conclusion is based upon defective specimens, I must dissent.

Compaıing examples of the several species in question with shallow tangential sections of ordinary Fenestellids we find that with a little diagrammatic restoration of the section, there is no essential difference, while the supposed "pore" is explained by the wearing away of the thin and slightly convex portion of the front of the cell. The dark matrix which has entered the cell is then clearly seen, and the weathered portion might readily be mistaken for a suboral pore. The thin septum which is said to separate the lower from the true aperture is nothing more or less than the superior hemiseptum, and when the attrition has proceeded to the extent that even this is removed then the general appearance of the cell with its two inflections looks precisely like what we see in tangential sections of most FENESTELLIDÆ.

All the dense portions of the zoarium, such as the base, the spiral axis of *Archimedes*, and diverging supports of *Lyropora*, as well as the stony deposit over the front and reverse of the zoœcia exhibit essentially the same structure. A finely laminated composition prevails throughout, and very delicate vertical tubuli, penetrating the laminæ, can, as a rule, be demonstrated. The tubuli again are generally arranged in series, and though varying in number are always abundant.

As regards zoarial features the genera *Semicoscinium* Prout, *Isotrypa* and *Unitrypa* Hall, and *Hemitrypa* Phillips, present several peculiarities that have at various times been called into question. The most serious objection to *Hemitrypa*, which was the only genus of the group generally known, comes from English palæontologists. In a paper entitled "A Review of the British Carboniferous Fenestellidæ," published in the Quart. Jour. Geol. Soc. for May, 1879, Mr. G. W. Shrubsole, after quoting some remarks by Lonsdale upon the genus, writes as follows: "There can be no doubt that the interior portion of the *Hemitrypa hibernica* (McCoy), is a *Fenestella*, nor need we be in any doubt as to the species. The difficulty has always been the external sheath. It is important to mention that the same form is parasitic on brachiopods and crinoids, as well as *Fenestella*. Its connection therefore with *Fenestella* is accidental and not structural. It is without doubt a small coral common to the limestone, very similar to *Flustra palmata* McCoy, the empty calices of which cover over and conceal the *Fenestella* underneath. *Hemitrypa*, as we have seen, has *Fenestella membranacea* Phillips for the ground work, and a microscopic coral or polyzoon for the super-structure." The next year in reviewing the Upper Silurian species of *Fenestella*, he treates of specimens of *F. prisca*, Lonsdale, which "are disfigured by the enveloping coral." This species most probably belongs to *Unitrypa*. "The growth of *F. prisca* is readily detected by the peculiar shape of the so-called fenestrules which are often twice as broad as long. What I take to be the tabulæ (!) of the coral occur more frequently than the dissepiments of the *Fenestella*." As regards Mr. S. R. Vine's stand-point it is enough to say he appears to have accepted Mr. Shrubsole's ultimatum without examining into the facts for himself.

When I think of the hundreds of exquisitely preserved examples of species of the genera in question that I have seen and studied, it seems almost ridiculous that argument is necessary to show them to be a structural unity and not composed of two separate and distinct organisms. It seems to me that Mr. Shrubsole must be lacking sadly in caution, as well as in respect for the work of others, or he would not express himself so dogmatically as in the above samples upon a question that manifestly he can scarcely have touched. Both Mr. Shrubsole and Mr. Vine could easily have verified the structural unity of the *Fenestella* interior and the supposed parasitic coral by making a few judicious thin sections of specimens preserved in limestone, those in shale being usually so much compressed that the union between the two fenestrated expansions is broken. Had they had an opportunity of examining some of the silicified specimens from the Falls of the Ohio river, which show the delicate net-work perfectly free from the matrix, I am sure their present views upon *Hemitrypa* and *Unitrypa* would never have been published. Still, as the outer structure of *Hemitrypa*, etc., is by many regarded as of the nature of a parasite, some refutation is required. I will therefore ask a few questions.

If the structure is viewed as a parasitic bryozoan similar to *Paleschara* Hall, or to Monticuliporoids of the type of *Lepto trypa*, upon what grounds is the supposition based? The zoœcium of a bryozoan must before all things have a *bottom* or *basal plate*. Is this present on the inner side of the external net-work? I answer emphatically, *no*. On the contrary the little openings communicate without any interruption with the interior space between the two expansions. It is true, of course, that over the basal portion of old examples of *Hemitrypa* and *Unitrypa*, the fenestrules on both surfaces of the zoarium are covered by a thin calcareous membrane, but this fact has no bearing whatever upon the question. Again, if the suspected expansion is of the nature of *Leptotrypa*, why do we not find clusters of large cells, which are invariably present in such forms? And why do the little openings in the superficial network of *Hemitrypa* correspond so exactly both in position and number with the zoœcial apertures beneath them in the celluliferous expansion? Surely this is not simply a coincidence.

Further, why is it impossible to detect a divisional line between the supposed parasite and the "disfigured" *Fenestella?* Upon what ground does Mr. Shrubsole base his assertion that the same parasite is found upon brachiopods and crinoids? In this country it is less erratic, besides being an exceedingly constant type, *Hemitrypa* fenestellids ranging from the Upper Silurian to the Carboniferous. Lastly if the cross bars of *Unitrypa* are, as claimed by Mr. Shrubsole, the tabulæ of a coral, will he not oblige us by publishing a description of the unique form? But let us pass on to something more interesting than this rather impertinent inquisition.

In *Semicoscinium* we have a type that commenced already in the Niagara group, with such aberrant forms of *Fenestella* as *F. tenuiceps* and *F. acmea.* In all its representatives the keel is very high, while, especially in the more typical forms, the branches are not rigid on the reverse side of the zoarium but appear to inosculate. The zoarium is funnel-shaped, with the upper portion more or less undulated and often decumbent. The poriferous side is the outer one, and the strong keels of the branches give this surface a vertically lined appearance. The base of the funnel, particularly in old examples, is smooth and spreads somewhat over the body to which it is attached. The smoothness is due to a thin membrane which is spread over the keels sometimes a considerable distance up the side of the inverted cone, the space between the keels and under the membrane being filled with vesicular tissue. The keels themselves are very thin immediately above the top of the branches, but are much thickened towards the summit, which in some cases is quite flat, but in others varies from obtusely to acutely ridge-shaped. The sides of the flattened keel summit is usually smooth, but in some they are crenulated (*S. planodorsatum* Ulrich, Pl. 44, fig. 3). By producing these crenulations into transverse connecting bars, we realize through certain intermediate species (e. g. *Fenestella? præcursor* Hall, and *F. bigeneris* Ulr.) what Hall has described as *Unitrypa.* The transverse bars that characterize this genus are really vertical plates which occur at very regular intervals (corresponding to the zoœcia) and are usually, if not always, suddenly bent backward, so as to give the intervening spaces the appearance of imbricating cell mouths. In *Isotrypa* Hall we have the same general construction as in *Unitrypa*, but the external aspect of the two expansions are so much alike, that it is sometimes difficult to distinguish between them. Indeed, the summits of the keels and the connecting bars are rounded and longitudinally striated, so that they might readily be mistaken for the reverse side of an ordinary species of *Fenestella*. Sections of a species of this genus are figured on plate LIV.

In the much disputed *Hemitrypa*, we find a somewhat different construction. In this genus the carina (which in *Semicoscinium*, *Unitrypa* and *Isotrypa* is a continuous plate) carries a close series of small pillars that support the favose superstructure. A regular series of arches connect the pillars and combine to form a longitudinal crest at intervals corresponding to the number of zoœcia. Short transverse bars proceed from each side of this crest and extend to the center of the space between two branches where they unite with a false crest which is usually somewhat thinner and more decidedly zigzag than the true crest. This arrangement of the bars and crests produces a delicate net-work, pierced by small and exceedingly regular hexagonal, petaloid, or circular openings, This brief description of the structure of *Hemitrypa* may be advantageously supplemented by a study of the sections figured on plates LIV and LVII. None of these are in any way diagrammatic but are drawn as near to nature as possible.

The free condition of the branches in species of *Thamniscus* induced King to establish another family for their reception.* In this course he is followed by Vine† and by Waagen and Pichl‡. Zittel, however, places the genus as a synonym under *Acanthocladia* King§, being under the erroneous impression that the two genera are distinguished only by differences in the arrangement of the zoœcia apertures. All of these authors agree in

* Mono. Perm. Foss. (Pal. Soc. Pub. vol. III, 1849.)

† 4th Rept. Brit. Assoc. on Foss. Poly. 1883 and Notes on Joredale Poly. of N. Lancashire, 1885.

‡ Palæontologica Indica, ser. XIII, part 5, 1885.

§ Handbuch der Pal. 1880.

placing *Acanthocladia* in the immediate vicinity. My arrangement is quite different. I find that there exists between *Thamniscus* and *Polypora* a very close chain of intermediate links. Examples of *T. dubius* (the type of the genus) now before me, clearly show that non-poriferous dissepiments occasionally connect the branches. In cell structure there is no difference between *T. dubius* and such species of *Polypora*, as *P. tuberculata* Prout, *P. cestriensis* and *P. spinulifera*. In species of *Thamniscus* the branches bifurcate in precisely the same manner, though as a rule more frequently than they do in *Polypora*. Such a slight difference can, of course, scarcely be taken into account as of even generic importance. Now as to the presence or absence of dissepiments, we must, because of their constant development in so many forms, regard them as a character of considerable value. But here again the "vanishing lines of nature" come into play, giving us an inkling of geneological relation. For instance, in *Polypora halliana* Prout, we have a true species of the genus, but upon comparison, it is found that the species is closely related to *P. maccoyana*, and this to *P. distincta* and *P. gracilis* (Prout.) The last is brought into close relation with *Thamniscus divaricans* by an undescribed form from the Keokuk group of Keutucky. In *P. halliana* and *P. maccoyana* there are from two to six dissepiments to each bifurcation, in *P. distincta* and *P. gracilis*, generally two, while in *T. divaricans* there are rarely two, generally one, and sometimes none. The same may be said of *T. ramulosa*.*

* *T. ramulosa* belongs to another line of development tending the same way through *P. cestriensis* and *P. tuberculata*. It is my opinion, and good evidence can be brought to support it, that the majority of the Carboniferous and Permian species of *Thamniscus* (including the type species) were developed from Devonian and early Carboniferous species of *Polypora*, such as I have mentioned, and not from Silurian and Devonian species now referred to *Thamniscus*. When it comes to the latter, we have but little evidence to show that they were derived from *Polypora*, yet the inference is fair that they were, and that *Polypora* always had within itself the tendency to assume the characters of *Thamniscus*. If this is admitted then we can admit that *Fenestella* also had a continual tendency to run into *Polypora*. Again many problems present themselves which can only be explained by supposing that the changed form reverted back into the parent stem. (A *Fenestella* graduallv assumed the characters of *Polypora* and vice versa). Hence, in all formations from the Niagara to the Coal Measures, there were intermediate forms between *Polypora* and *Fenestella*. These species, the evidence leads me to believe, were more often derived from typical species of the genera than from each other.

From whatever point the question may be viewed, no one can deny the relation between the genera as here outlined. As regards the relation generally supposed to exist between *Acanthocladia* and *Thamniscus*, my investigations have convinced me that it has no real foundation in nature. That the branches in the two genera are free is of little consequence, since there are differences of far greater import. In fact, *Acanthocladia* is constructed upon the same plan as *Pinnatopora* Vine (*Glauconome* of authors), *Synocladia* King, and *Septopora* Prout. In these four genera comprising the bulk of the ACANTHOCLADIIDÆ, as here defined, the zoarium consists of primary and secondary branches, the latter being smaller and arranged in a pinnate manner on each side of the former. In the two first the secondary branches are never united, bnt in *Synocladia* and *Septopora*, those which spring from adjacent primary branches coalesce so as to produce a reticulated expansion.

As Mr. G. R. Vines arrangement of the Bryozoa under consideration is quite different from that adopted by me, it is but justice to the student that some mention be made of it. He restricts the family FENESTELLIDÆ to fenestrated or non-fenestrated forms in which the zoœcia are "arranged biserially in the branch." The four genera *Fenestella*, *Ptilopora* McCoy, *Pinnatopora* and *Septopora*, he groups under this head. The new family DIPLOPORIDÆ he proposes for the reception of *Diplopora*, *Acanthopora* and *Actinostoma*, three genera previously proposed by Messrs. Young and Young as subgenera of *Fenestella* and *Glauconome*. For *Polypora* and *Phyllopora* King he proposes the POLYPORIDÆ. Lastly, Kings family THAMNISCIDÆ, containing *Thamniscus*, *Acanthocladia* and *Ichthyorachis* McCoy, is accepted by him.

This classification is so obviously artificial that the probabilities are very much against its acceptance by any one who will undertake an extended study of the forms in question. His definition of the FENESTELLIDÆ would include *Phylloporina dawsoni*, and the Permian *Phyllopora ehrenbergi* since in both the zoœcia are arranged in two series. What would he do with such forms as *Polypora whitei*, *P. radialis*, *P. biserialis*, *P. celsipora* Hall, *P. arta* Hall, and *P. incepta* Hall? They would figure equally as well under his FENESTELLIDÆ as under the POLYPORIDÆ, *Lyropora* Hall, would go partly in one family, and the remainder in the other. And why separate *Pinnatopora* and *Septopora* from *Acanthocladia* and *Ichthyorachis?* Simply because the former have only two rows of zoœcia, and the latter three or more? Such a difference is surely not sufficient to outweigh the important points of agreement above mentioned; no, it does not require a very extended knowledge of the Fenestellids to become convinced of the inadequacy of variations in the number of ranges of cells as foundations for families, yes, scarcely even for genera. As to the three genera which he groups under the name DIPLOPORIDÆ, I should say that *Actinostoma* is founded upon a species of *Fenestella*, in which the radial ribs of the opercular closures of the zoœcial orifice were not obliterated by deposits of calcareous material. I have seen these more or less distinctly preserved in a number of the FENESTELLIDÆ (species of *Fenestella*, *Polypora*, *Lyropora* and *Pinnatopora*) and believe that they were generally present in these Bryozoa. *Acanthopora* Y. & Y., stands in the same relation to *Pinnatopora*.* As regards *Diplopora* Y. & Y., I shall view the division in the light of a valid genus, but not upon the characters mentioned by Mr. Vine and the authors of the genus. For discussion of this point see remarks upon the genus further on. With regard to the POLYPORIDÆ and THAMNISCIDÆ, nothing farther need be said, as my opinion of them is already sufficiently expressed.

Waagen and Pichl's arrangement of the FENESTELLIDÆ differs somewhat from that proposed by Vine. They divide the family into three sub-families, of which the first, the FENESTELLINÆ, contains, *Fenestella*, *Fenestralia* Prout, *Septopora*, *Lyropora*, *Ptilopora* McCoy, *Helicopora* Claypole, and *Archimedes* Lesueur. In the POLYPORINÆ they propose to include *Polypora*, *Phyllopora*, *Synocladia* and *Dendricopora* DeKoninck,

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* The name *Acanthopora* has priority over *Pinnatopora* of Vine, having been proposed in 1875, but as it is less appropriate than the latter and was erected upon what I believe to be defective specimens, and only as a provisional subgenus under *Glauconome*, it seems desirable to drop the name in favor of Vine's, which was well characterized and established for the reception of species not intended to be covered by *Acanthopora*.

while for *Goniocladia* Ethridge and *Ramipora* Toula the subfamily GONIOCLADINÆ is erected.

This classification has as little, or even less merit than Vine's, being based upon the presence or absence of a median keel, a character shown by experience to be unreliable. All the genera in the first and second divisions, excepting *Septopora*, *Synocladia*, and, probably, *Ptilopora* and *Dendricopora*, belong to the FENESTELLIDÆ as here defined, but *Goniocladia* is very different, being related to the CYSTODICTYONIDÆ, where I would place it provisionally. *Ramipora* is doubtful, and before its position can be determined, must be subjected to recent methods of investigation.

The typical genera of this and the following family have heretofore been regarded, I believe, universally, as CYCLOSTOMATA. This now seems to be a wrong collocation, resulting from defective observation of certain deceptive peculiarities in their structure. In the first place the zoœcia have always been described as tubular. This, however, is an error, as only the vestibular prolongation of the orifice is tubular, the true zoœcium being an horizontal cell of quadrate or hexagonal form, with both ends truncated. The aperture, furthermore, is not situated at the end of a tubular zoœcium as in the CYCLOSTOMATA, but occupies the anterior portion of the upper side (front) of the cell; in short, the cell agrees in form with those of the Escharine group of the CHILOSTOMATA, to the same extent as those of *Ptilodictya* and other genera referred to the new sub-order CRYPTOSTOMATA. Vine, in briefly discussing the subject, brings out another point in their structure, which he compares to the foraminated condition of the walls of the TUBULIPORIDÆ, namely, the minute tubuli which penetrate the dense deposits of laminated sclerenchyma on both the front of the zoœcia and the basal plate on the reverse side of the zoarium.

Admitting provisionally the propriety of the comparison, I ask, will it not apply fully as well to the CHILOSTOMATA, since a foraminated cell front is well known to be present in many genera of the sub-order? Why should the answer not be *yes*, and, if we take other points of structure into consideration, *better?* My space being limited, I am not at liberty to enter into any extended discussion of this and other points bearing upon the question, but as it is an important one, I will mention briefly some of my reasons for removing the families from the CYCLOSTOMATA.

First, the zoœcia of the FENESTELLIDÆ and ACANTHOCLADIIDÆ are not tubular, but agree closely in form and general structure with those of the PTILODICTYONIDÆ and ESCHARIDÆ.* Second, the primary orifice is drawn out into a shaft-like vestibule, precisely as in typical members of Mr. Vine's new sub-order CRYPTOSTOMATA. Third, the structure of the secondary deposit over the cells and basal plate, differs in no essential manner from that of the dense tissue which forms the non-poriferous margins and pointed base of *Ptilodictya,* and the deposit over the basal portions of the zoaria of many CYSTODICTYONIDÆ. Fourth, one or both of the structures that I have called superior and inferior hemisepta are usually (perhaps always) present. These four reasons refer to such weighty points of structure that I am content to rest the question upon them without detailed explanation. The critical student can, without much labor, corroborate at least some of the abundant evidence relating to the points at issue given on the plates attached to this volume.

(5) ACANTHOCLADIIDÆ:—The minute structure of this family is so much like that of the preceding, that for present needs it is sufficient to point out the features upon which the family is maintained.

The zoaria are generally pinnate, often fenestrated, and rarely dendroid, differing from those of the FENESTELLIDÆ in consisting of primary and secondary branches, and in being without non-poriferous dissepiments. The primary branches are strong straight stems, which usually remain simple, but in a few cases are known to bifurcate. The secondary branches are nearly always considerably smaller than the primary ones, from the two opposite margins of which they are given off. In *Synocladia* and *Septopora* the secondary branches unite with those of adjacent branches, thus forming reticulate expansions. From

* In a few species the secondary deposit upon the cells was very slight. These resemble Chilostomatous Bryozoa in a marked degree. In describing one of these forms (*Pinnatopora? simplex*) Mr. Vine states (Notes on Yoredale Poly.) that it reminds one of Chilostomatous rather than of Cyclostomatous Bryozoa.

the margins of the primary branches new ones are given off at the same angle as the secondary branchlets, and these again are provided with branchlets the same as the original stem (see Pl. LXVI, figs. 7 and 8).

From the above it will be seen that the ACANTHOCLADIIDÆ and FENESTELLIDÆ are distinguished by a zoarial difference, but this difference is merely the result of some peculiarity in the development of the zoœcia, causing celluliferous branchlets to take the place of solid dissepiments. In *Ptilopora* McCoy, which might with equal propriety be arranged with the FENESTELLIDÆ, we have intermediate conditions. It is a type that commenced in early Devonian times with species of *Fenestella*, in which some of the branches were disproportionately thickened, and the thinner branches at the same time arranged in an indistinct pinnate manner. The type cannot rank as a separate family, and the ultimate position of the genus depends largely upon the relative importance attached to the presence of dissepiments on the one hand and the pinnate arrangement of the zoarium on the other. (See remarks on the genus further on).

(6) SPHRAGIOPORIDÆ:—This family is proposed for the reception of a single genus, of which, so far as I have seen, only one or possibly two species are known. This is, however, so distinct from all the previously established families, that I feel justified in adopting the course here pursued. For particulars relating to the structure of this unique bryozoan, the reader is referred to the specific description further on.

(7) PHYLLOPORINIDÆ:—The genera comprised in this family have been established upon species usually referred, heretofore, to the FENESTELLIDÆ. A minute comparison of their interiors having brought to light certain peculiarities in zoœcial structure, a new family seems to be demanded for them. These distinctive features have already been pointed out in my general remarks on classification, and to prevent repetition, the reader is referred there, and to the descriptions in the subjoined synopsis of classification.

(8) ARTHROSTYLIDÆ.—This interesting family of Bryozoa, especially in its typical members, reminds one of the recent CELLARIDÆ, yet beyond the articulated zoarium and a general

external resemblance, but little can be brought showing true relationship. On the contrary, in the form of the zoœcia there is close agreement between them and the STICTOPORIDÆ. It also appears highly probable that the ARTHROSTYLIDÆ constituted a distinctively Silurian type, since no representatives are as yet known from either the Devonian or Carboniferous systems.

The jointed condition 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 excepting *Nematopora*, in which the zoarium is a dichotomously branching stem above the basal articulating extremity. (Pl. XXIX, fig. 11a). In *Helopora* Hall, *Sceptropora* Ulr., and *Arthrostylus* Ulr., the segments are simple and terminally joined together. In *Arthroclema* Billings, the zoarium forms a plumose expansion, and is 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 two opposite sides of each of the joints of the first and second series, in which the first of the series of the second and the third order is inserted.

The zoœcia are arranged in a radial manner around a central axis, and, excepting *Arthrostylus*, open on all sides of the subcylindrical segments. In the excepted genus one of the sides is marked only with longitudinal striæ. The primitive cell is wedge-shaped, but inclined to be tubular in the larger species. As nearly all of the zoœcia commence at the center of the zoarium the reason is obvious; their form must adapt itself to the distance between the axis and the surfaces, and as it is greater in the large species than in the smaller, the primitive cell appears, consequently, somewhat tubular (compare figs. 15 and 18). Ordinarily they are oblong quadrate or hexagonal in outline, and aside from their wedge-like shape (due to their arrangement) agree closely with those of the STICTOPORIDÆ. "Hemisepta" I have not observed.

(9) RHABDOMESONTIDÆ:—This interesting family must be regarded as forerunners of the VINCULARIDÆ. Indeed the external resemblance to species of that later type is often so very striking that a real affinity between them is forcibly suggested. Minute comparisons show, however, that the differences which distinguish the groups of Palæozoic Bryozoa from their more recent

representatives also prevail in this case. Namely, the zoœcia are more tubular than those of the Vincularids, while the secondary deposit which gave rise to the "vestibule" of the CRYPTOSTOMATA is wanting in them. In other respects the closest agreement can be shown. On the other hand the RHABDOMESONTIDÆ are intimately connected with the BATOSTOMELLIDÆ of the TREPOSTOMATA, and it is sometimes very difficult to draw the line between *Rhombopora* and the genera of that family. The genus *Rhombopora* also embraces species that compare very favorably with *Streblotrypa*. In fact the genus contains some very diverse yet intimately related forms of which each points in widely different directions.

In *Rhabdomeson* Y. and Y., the zoœcia are arranged round an axial tube precisely the same as in the cretaceous *Siphonella* of Hagenow. Such an axis does not exist in *Rhombopora* nor have I yet seen an American species of this family in which it is present. The structure of the zoœcia is about as follows: Their primitive portion is always tubular and enclosed by exceedingly thin walls. Their proximal ends may be attached to an axial tube (*Rhabdomeson*), or they may originate along an axial line around which they are wedged in a radial manner (*Rhombopora incrassata*, Pl. LXX, fig. 12d) or they are produced by germination throughout the axial region (*R. subannulata*, Pl. XLV, and *R. tabulata* and *R. minor*, Pl. LXX). Here too the longer tubes may be intersected by one or more complete diaphragms. These structures must not be confounded with the hemisepta which are usually present at the point of outward bending and thickening of the walls. As in *Ptilodictya*, two or more pairs of hemisepta may be developed in old examples, but in most cases the inferior hemisepta appear to be absent, (Pl. XLV, fig. 1h, and Pl. LXXI, fig. 3c). The aperture is circular or elliptical and, with only few exceptions, surrounded by a sloping area, typically rhombic or hexagonal in outline, causing the inter-apertural space to be ridge-shaped. The summit of the ridge carries from one to three series of minute granules, while an acanthopore is commonly found at the angles of junction.

As already intimated the family foreshadows the VINCULARIDÆ. Among Palæozoic Bryozoa the BATOSTOMELLIDÆ offer the most points of resemblance. The relationship to *Stenopora* would scarcely be even suggested by a comparison between the typical species of that genus and of *Rhombopora*, yet, when the comparison is extended to a large number of species, it becomes clear enough. For instance, *Stenopora ramosa* and *Rhombopora crassa* Ulr., may be compared through *Stenopora? signata*. A clear line of relation passes from—say, *Rhombopora dichotoma*, through *R. incrassata*, *Anisotrypa? elegantula* Ulr., and *A. solida*, to *Stenopora ramosa*. Again, if we pass from *R. simulatrix*, *R. decipiens*, *R. tabulata* and *R. minor* to *R.? asperula*, but a short step is required to bring us to *Batostomella nitida* and *B. spinulosa*.

Despite the close relationship suggested by the above lines of comparative inquiry, I have placed the two families in different suborders. My reason for doing so is that, notwithstanding the numerous points of agreement, there always remains one peculiarity to distinguish them. This is the presence of hemisepta in the RHABDOMESONTIDÆ, and their absence in the BATOSTOMELLIDÆ. These structures are known only among the CRYPTOSTOMATA, of which they constitute one of the most important and characteristic features. That the primitive portion of the zoœcia of this family is tubular, is, I believe, largely accounted for by the fact that the distance from the center of the branches to their surface is too great to admit of short cells. The much shorter zoœcia of the new genus *Cœloconus*, which compare favorably with those of the STICTOPORIDÆ, lend plausibility to this view. Still I would not for a moment deny the importance, from a morphological point of view, of the relationship above shown.

(10) STREBLOTRYPIDÆ:—In this family the zoarium may be ramose, bifoliate, or unilaminar, the primitive portion of the zoœcia tubular in the first, and sub-tubular in the other modes of growth. Hemisepta may be present or wanting. The aperture which is usually circular, or elliptical is in other forms decidedly truncated at the posterior margin. The front of the cell back of the aperture, is simply depressed or exhibits from two to twelve or more small pits. When the latter are numerous they are generally arranged in two longitudinal series.

This family will provisionally include *Streblotrypa*, *Worthenopora*, *Cyclopora* Prout, *Proutella* and *Hyphasmopora* R. Ether. jr., the last mainly upon the authority of Mr. Vine, who considers the genus related to *Streblotrypa*.

As regards the systematic position of the genera, I should say that *Cyclopora fungia* Prout, is related to the Ptilodictyonidæ (compare fig. 2b and 11c in text with fig. 3c, d, and e, on Pl. LXVIII); *Streblotrypa* compares on one side with *Rhombopora*, and on the other agrees in important features with *Intrapora basalis*. In *Worthenopora* and *Proutella*, I believe we see the nearest approach to the *Escharidæ* yet known from Palæozoic rocks, but as careful search of many specimens has failed to reveal accessory cells of any kind, it has appeared better to arrange the genera with the STREBLOTRYPIDÆ than with that family.

(11) HELIOTRYPIDÆ:—This provisional family is founded upon the peculiar genus *Heliotrypa*. For its characters the reader is referred to the original description and figures* and to the following synopsis of classification.

V. CHILOSTOMATA:—*Paleschara* Hall, is the only Palæozoic genus that my present views will admit of placing in this suborder. As near as I can determine, the affinities of the genus, for which the new family PALESCHARIDÆ is proposed, are nearer to the MEMBRANIPORIDÆ than to any other.

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*Am. Pal. Bry., Jour. Cin. Soc. Nat. Hist., vol. 6, p. 277, 1883.

SYNOPSIS OF CLASSIFICATION.

Order GYMNOLÆMATA Allmann.

Sub-order CTENOSTOMATA Busk.

Family ASCODICTYONIDÆ Ulrich.

Zoaria adnate, consisting of radially arranged filiform, fusiform, or bulbous zoœcia; or of sub-fusiform uniserial cells. Substance? corneo-calcareous.

ASCODICTYON Nicholson and Ethridge, jr.—Zoœcia consisting of radially arranged, fusiform or bulbous zoœcia, or filiform threads with periodic swellings.

Type: *A. fusiforme* Nich. and Ethr. jr. Range, Cincinnati group to Coal Measures.

RHOPALONARIA Ulrich.—Cells slender, fusiform, arranged in a single anastomosing series. Cell mouths small, near one end of the cells. The animal had the power of excavating the substance of the body upon which it grew.

Type: *R. venosa* Ulr. Range, Trenton and Cincinnati.

Suborder CYCLOSTOMATA Busk.

Family TUBULIPORIDÆ Busk.

STOMATOPORA Bronn.—Zoaria adnate, with the zoœcia in a single branching series. Zoœcia tubular, the apertures circular, more or less elevated, subterminal. Walls finely porous.

Type: *S. dichotoma* Lamx. Range, Trenton to Recent.

PROBOSCINA Audouin.—Like the preceeding, but with the cells in two or more series, and the apertures slightly constricted.

Type: —?— Range, Cincinnati to Recent.

BERENICEA Lamx. (*Sagenella* Hall).—Zoaria forming delicate incrustations upon foreign bodies; sometimes consisting of several superimposed layers. Zoœcia as in the preceding.

Type: *B. diluviana* Lamx. Range, Trenton to Recent, but not as yet known from Devonian and Carboniferous strata. The same is true of Stomatopora and Proboscina.

Clonopora, *Cystopora*, *Hederella*, *Ptilionella** and *Hernodia*, are genera lately proposed by Prof. Hall. Judging from his brief descriptions only, it seems probable that they refer to Bryozoa having affinities with the TUBULIPORIDÆ. All are from Devonian deposits.

Family FRONDIPORIDÆ Reuss.

SCENELLOPORA Ulrich.—Zoaria broad-obconical, the under side with an epitheca, the upper slightly concave and celluliferous. Zoœcia with subcircular apertures, occupying the summits of radiating ridges. Intermediate spaces smooth, without cells.

Type: *S. radiata* Ulr. Range, Trenton.

Family PHACELOPORIDÆ n. fam.

Zoaria segmented; the zoœcia conical, combined in bundles of two or more to form conical segments.

PHACELOPORA n. gen.—Zoarium articulated; segments short, conical, consisting of two or more equal, conical zoœcia, with slightly contracted circular apertures.

Type: *P. pertenuis* Ulr. Range, Trenton to Cincinnati.

Family ENTALOPHORIDÆ Reuss.

DIPLOCLEMA n. gen.—Zoaria ramose, ovate in cross section. Zoœcia tubular, long, apparently moniliform proximally, separated internally by an axial lamina from which they gradually diverge to open up on the two sides of the compressed branches. Apertures prominent, isolated, somewhat constricted and circular. External wall thin.

*This genus is the same as *Reptaria* proposed Rolle in 1851. (See Pal. N. Y. Vol. 6.)

Types: *D. trentonense* n. sp.,* from the Trenton group of New York, and *D. sparsum* (*Trematopora sparsa* Hall) from the Niagara group.

MITOCLEMA Ulrich.—Zoaria ramose, slender, subcircular in transverse section. Zoœcia tubular, very long, gradually diverging in all directions from an imaginary axis. Apertures prominent, circular, arranged in transverse series around the stems. Walls thin.

Type: *M. cinctosum* Ulrich. Range, Chazy. (For internal structure see Pl. LIII).

PROTOCRISINA n. gen.—Zoaria ramose, celluliferous on one side only. Zoœcia subtubular, with prominently exerted circular apertures. Reverse finely grano-striate. Small pores, apparently communicating with the interior of the zoœcia, are rather irregularly distributed over both sides of the branches. Axis thin, cruciform in transverse section. External walls thick.

Type: *P. exigua* n. sp. (Pl. LIII, fig. 11-11c). Range, Trenton and Cincinnati.

Sub-order TREPOSTOMATA Ulrich.

Family MONTICULIPORIDÆ Nicholson.

(Emended and restricted.)

Zoaria massive, discoid or lamellar, ramose or bifoliate. Zoœcia with thin and probably minutely perforated walls, the peculiar granular structure exhibited in thin sections being strongly indicative of an originally porous condition. Apertures polygonal, rounded, or irregularly petaloid. Mesopores

* *Diploclema trentonense* Ulr.—As this species has not yet been described, I append here a brief diagnosis of its characters. Zoarium slender, ramose, dividing dichotomously at an angle varying from 70 to 90 degrees; intervals between divisions, 5 mm., a little more or less. Branches 0.55 mm. wide, 0.35 to 0.4 mm. thick. Zoœcia tubular, in tangential sections faintly moniliform near their origin. Apertures slightly constricted, prominent, circular, 0.1 mm. in diameter, in three or four rows on each side of the branch; generally arranged in oblique rows, less commonly transversely; at other times irregular, four or five in 2 mm. measuring longitudinally; transversely the interspaces are shorter.

The species is quite common at Trenton Falls, N. Y. The internal structure of both *D. trentonense* and *D. sparsum* is figured on Pl. LIII.

occasionally wanting, in other cases numerous; when present they are angular and intersected by crowded horizontal diaphragms, often obscured by a secondary deposit. Acanthopores abundant. Cystiphragms always present in the mature region.

MONTICULIPORA d'Orbigny.—Zoaria massive, lobate or lamellate, incrusting or free. Surface with monticules, or even. Zoœcia polygonal, thin-walled. Mesopores very few, generally entirely absent. Acanthopores more or less numerous.

Type: *M. mammulata* d'Orb. Range, Trenton to Hamilton.

ATACTOPORELLA Ulrich.—Zoaria generally forming thin crusts over foreign bodies, rarely lobate, or subramose. Surface with monticules. Zoœcia with very thin inflected walls, the apertures irregularly petaloid. Mesopores numerous, frequently isolating the zoœcia, and largely filled, especially near the surface, by a secondary deposit. Acanthopores very abundant, generally encroaching upon the zoœcial cavity.

Type: *A. typicalis* Ulr. Range, Trenton to Cincinnati.

HOMOTRYPELLA Ulrich.—Irregularly ramose. Monticules wanting, small maculæ usually present. Zoœcia with moderately thick or thin walls. Apertures sub-circular, sometimes faintly petaloid. Mesopores abundant, more or less completely isolating the zoœcia. Cystiphragms generally developed only in the median region of the zoœcial tubes, being usually absent just beneath the surface and never present in the axial region. Acanthopores numerous.

Type: *H. instabilis* Ulr. Range, Trenton to Clinton.

PERONOPORA Nicholson.—Zoaria bifoliate, the surface even, usually with small maculæ. Mesopores and acanthopores varying in number. Cystiphragms abundant, present throughout the mature region in the zoœcial tubes. Apertures circular or polygonal. Zoœcial walls comparatively thick, sometimes ring-like in transverse section.

Type: *P. decipiens* Rominger, sp.—Cincinnati group.

HOMOTRYPA Ulrich.—Ramose to frondescent, with or without monticules. Mesopores occasionally wanting, always few, sometimes gathered into clusters. Zoœcial tubes with very thin walls and remote diaphragms in the large axial or immature region;

cystiphragms are developed just before opening at the surface. Apertures subcircular or polygonal, the shape depending on the thickness of the interspaces. Under favorable circumstances tangential sections exhibit what appears to be large communication pores.

Type: *H. curvata* Ulrich. Range, Trenton to Niagara.

PRASOPORA Nicholson and Ethridge.—Zoaria forming hemispheric, discoid, or irregular masses, and, more rarely, thin expansions; usually free, with an epithecal covering on the lower side. Zoœcial tubes prismatic or cylindrical, thin-walled, largely separated from each other by small angular mesopores, which are generally quite inconspicuous at the surface. Acanthopores usually present, but only occasionally either numerous or strong. Cystiphragms in all the zoœcial tubes. Diaphragms crowded in the mesopores.

Type: *H. grayæ* Nich. and Ethr. Range, Trenton to Cincinnati.

Family HETEROTRYPIDÆ n. fam.

Zoaria frondescent, ramose or parasitic. Zoœcia polygonal, walls comparatively thin and more or less contiguous; rarely sub-oval, with thick walls. Line of separation between adjoining zoœcia more or less clearly defined. Mesopores varying from very few to numerous. Acanthopores present, sometimes of large size. Diaphragms numerous, usually horizontal. Cystiphragms wanting.

HETEROTRYPA Nicholson.—Zoaria frondescent, sub-ramose, or, rarely, incrusting. Zoœcial tubes prismatic, sometimes subcylindrical. Apertures angular, sub-circular, or slightly petaloid. Walls moderately thin. Mesopores varying in number, sometimes abundant, with illy defined walls. Acanthopores small, generally numerous. Diaphragms well developed, usually horizontal; sometimes a few may be concave or recurved.

Type: *H. frondosa* d'Orb. sp. Cincinnati group.

DEKAYIA Edwards and Haime.—Ramose; branches cylindrical or compressed. Zoœcia polygonal, walls thin. Mesopores few, restricted to the monticules or maculæ. Acanthopores originating in the axial region, sometimes very large, in other cases more numerous and smaller. Apertures closed at intervals by a thin calcareous pellicle.

Type: *D. aspera* Edwards and Haime. Range, Trenton to Hamilton.

PETIGOPORA Ulrich.—Zoaria parasitic, with a narrow non-poriferous band along the outer margin. Mesopores absent. Acanthopores well developed, abundant.

Type: *P. gregaria* Ulr. Range, Trenton to Cincinnati.

DEKAYELLA Ulrich.—Ramose, branches sometimes compressed. Mesopores more or less numerously distributed among the zoœcia, and often aggregated into irregular "maculæ." Acanthopores of two sizes, the smaller ones the most abundant and only present in the peripheral region. Those of the large size commence in the axial region. Diaphragms horizontal.

Type: *D. obscura* Ulr. Cincinnati group.

Family CALLOPORIDÆ, n. fam.

Zoaria ramose, sub-frondescent, or discoidal. Zoœcia generally sub-circular, rarely polygonal, separated from each other more or less completely by angular mesopores. Walls usually thin, sometimes thickened and ring-like in transverse section. Apertures closed by centrally perforated covers, which, as growth proceeds, are left behind in the tubes to form the floors of the succeeding chambers. Acanthopores wanting in the typical forms, very small when present.

CALLOPORA Hall.—Ramose to sub-frondescent, or sub-pyriform, smooth or tuberculated. Zoœcia with thin walls varying, according to the number of mesopores, from circular to polygonal. Apertures in the perfect state closed by opercular covers; perforation small, central, generally surrounded by radiating ridges. Mesopores angular or rounded, more or less numerous, sometimes completely isolating the zoœcia, with crowded diaphragms. Zoœcial tubes slowly attaining their full development, closely tabulated near their origin in the axial region; the diaphragms more distant farther along in the tubes. Transverse sections show that the tubes in the axial region are of two sizes, the larger ones sub-circular, the smaller set angular. This is one of the most characteristic features of the genus.

Type: *C. elegantula* Hall. Range, Trenton to Lower Helderberg.

Aspidopora Ulrich.—Very thin free expansions, with a concentrically and radially striated epitheca covering the lower side; rarely parasitic. Typically composed of (according to age) from one to many unequal spaces. Cells gradually increasing in size from the margin of each convex space to near the center of same. Mesopores numerous. Both kinds of tubes crossed by diaphragms. Small acanthopores present.

Type: *A. areolata* Ulr. Cincinnati group.

Calloporella Ulrich.—Free or encrusting, thin expansions. Surface smooth or undulated. Zoœcial tubes cylindrical, with thick walls, separated by one or two rows of angular mesopores. Zoœcia apertures sub-circular, arranged in regular intersecting series. Diaphragms numerous, straight. Acanthopores small and few.

Type: *C. harrisi* Ulrich. Cincinnati to Niagara.

Family Trematoporidæ n. fam.

Zoaria ramose, irregularly frondescent, or parasitic. Zoœcial tubes thin-walled and prismatic in the immature, sub-cylindrical in the mature region. Apertures circular, oval, or petaloid, with a more or less distinct peristome. Mesopores angular, abundant, usually isolating the zoœcia, closed at the surface; the closure with numerous perforations showing as small hollow spines or granules. Acanthopores often wanting. Zoœcial tubes and mesopores with diaphragms.

Trematopora Hall. Zoaria ramose; branches solid, even or montiferous. Zoœcia with oval or sub-circular apertures, surrounded by a 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 of moderate or small size usually present.

Type: *T. tuberculosa* Hall. Range, Trenton to Niagara.

NICHOLSONELLA n. gen.—Zoaria consisting of irregularly intertwining flattened branches or fronds, sometimes laminated. Zoœcia tubular, with a few diaphragms in the "mature" region. Apertures circular, with a faint granose peristome. Interspaces wide, occupied by numerous angular mesopores, that more or less completely isolate the zoœcia. Walls of both the zoœcia and mesopores thin, and in the mature region traversed longitudinally by minute tubuli. The interzoœcial spaces are filled with a calcareous deposit, into which the minute tubuli continue, but in which the mesopore walls become unrecognizable. Mesopores with rather thick and numerous diaphragms.

Type: *N. ponderosa* n. sp. Range, Trenton and Cincinnati.

CONSTELLARIA Dana.—Subramose or frondescent zoaria. 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 and peristome, equally distributed and partly in contact with each other in the spaces between the stellate maculæ. Mesopores abundant, aggregated in the maculæ, always closed at the surface, with gradually crowding horizontal diaphragms. Zoœcial tubes with few or moderately numerous diaphragms. True acanthopores wanting.

Type: *C. florida* Ulr. Range, Trenton to Cincinnati.

STELLIPORA Hall.—Zoaria forming thin crusts over foreign bodies. The upper surface exhibiting at rather irregular intervals stellate monticules. Zoœcia with sub-circular apertures occupying only the summits of the radially arranged short ridges, the depressed central space and furrows between the ridges, as well as the intermacular spaces, appearing non-celluliferous at the surface. Thin sections, however, show them to have been occupied by rather small, angular mesopores, which are more closely tabulated than the zoœcial tubes, and like them arise from the epithecal membrane.

Type: *S. antheloidea* Hall, from the Trenton limestone.

IDIOTRYPA Ulrich.—Zoaria parasitic. Zoœcia sub-circular, with a faint peristome, separated from each other by a series of large irregular closed mesopores,. Zoœcia and mesopores not distinguishable in vertical sections, both being crossed by thick parallel diaphragms, occurring at short and regular intervals. Diaphragms apparently perforated by numerous minute foramina. Walls with numerous minute vertical tubuli or cells.

Type: *I. parasitica* Ulrich. Trenton and Niagara.

Family BATOSTOMELLIDÆ n. fam.

Zoaria multiform, often consisting of superimposed layers; never bifoliate. Zoœcia with thick walls in the mature region, where they usually appear fused together. Diaphragms horizontal, those in the peripheral region centrally perforated, originally functioning as covers to the cell apertures. Mesopores usually present, often intermittent, generally without diaphragms and distinct walls; when abundant they are small. Acanthopores well developed.

BATOSTOMELLA Ulrich.—Ramose, branches slender, without monticules. Zoœcia thick-walled in the peripheral region, intersected by remote, delicate, originally perforated diaphragms. Apertures small, circular or oval. Interspaces rounded, thick, spinulose; the acanthopores small and usually very numerous. Mesopores subcircular, small, varying in number.

Types: *B. spinulosa* n. sp., and *B. gracilis* Nicholson. Trenton to Coal Measures.

STENOPORA Lonsdale.—Zoarium ramose, sublobate, massive, laminar or parasitic. Surface even or montiferous. In the mature region the zoœcial tube walls are periodically thickened so as to appear moniliform in vertical sections. Comparatively large acanthopores are developed at the angles of the cells. Diaphragms straight, more or less numerous, with a large central perforation; a few irregular mesopores occasionally present.

Type: *S. tasmaniensis* Lonsdale. Ranges through the Carboniferous system.

ANISOTRYPA Ulrich.—Zoaria ramose; branches irregular, hollow, and lined on the inside with an epithecal membrane; or more regular and solid. Zoœcia with subcircular apertures. Interspaces ridge-like, the comb sometimes with a series of extremely minute granules. Acanthopores and mesopores wanting.

Type: *A. symmetrica* Ulrich. Range, Keokuk to Chester.

BYTHOPORA Miller and Dyer.—Zoaria consisting of very slender ramulets. Zoœcial apertures oblique, lanceolate, narrowing above. Interspaces varying in thickness, often channelled. Diaphragms practically wanting. Mesopores very few or absent. Acanthopores comparatively strong, not numerous, rarely more than one to each zoœcium, sometimes wanting.

Type: *B. fruticosa* M. and D. Range, Trenton to Lower Helderberg.

CALLOTRYPA Hall.—Zoaria ramose, slender, solid. Zoœcia small, oval, separated by one or two series of shallow often elongated mesopores. An acanthopore sometimes present at the inferior margin of the aperture.

Types: *C. unispina* Hall, and *C. multiseriata* Hall. Range, Lower Helderberg to Hamilton. The genus will include, beside the two species named, Hall's *C. heteropora*, and *C. oculifera*.

LEIOCLEMA Ulrich.—Zoaria ramose, lamellar, sub-globose, or parasitic. Surface frequently exhibiting distinct monticules or maculæ. Zoœcia with sub-circular or irregularly petaloid apertures, separated by abundant angular mesopores, which appear to be open at the surface in the typical species and closed in others. Acanthopores numerous, situated in the walls of the zoœcia, strong in the typical forms, (giving the surface a spinous character) and very small and inconspicuous in another group of species. Diaphragms few in the zoœcial tubes, fairly abundant in the mesopores of the typical section, crowded in the majority of the species now provisionally referred to the genus.

Type: *Callopora punctata* Hall. Range, Cincinnati to Chester.

Family AMPLEXOPORIDÆ n. fam.

Zoaria ramose, incrusting, discoidal, or massive, rarely bifoliate. Zoœcia comparatively simple, prismatic, with a well marked divisional line between the walls of adjoining cells. Mesopores practically absent, but small abortive cells sometimes occur among the large zoœcia forming the monticules. Acanthopores sometimes absent, generally abundant.

AMPLEXOPORA Ulrich.—Zoaria ramose. Zoœcia polygonal, forming prismatic tubes, which are thin-walled in the axial region and more or less strongly thickened in the peripheral. Mesopores wanting. Acanthopores always present, varying in size and number. Diaphragms complete, horizontal.

Type: *A. cingulata* Ulrich. Range, Trenton to Hamilton.

MONOTRYPELLA Ulrich.—In most respects like *Amplexopora*, but differing in the absence of acanthopores. In one section of the genus, the zoœcia are often separated from each other in the peripheral region by closely tabulated interspaces, that simulate mesopores.

Type: *M. æqualis* Ulrich. Range, Trenton to Hamilton.

PETALOTRYPA n. gen.—Zoaria bifoliate, consisting of irregular, compressed branches or simple fronds, celluliferous on both sides. Zoœcial tubes prismatic, arising from a strongly flexuous mesial line. Apertures subcircular or polygonal. Mesopore-like interspaces that do not differ in their tabulation from the zoœcia may occur. Very small acanthopores (?) occupy many of the angles of junction.

Type: *P. compressa* n. sp. Range, Lower Helderberg to Hamilton.

ATACTOPORA Ulrich.—Zoaria thin, incrusting, often composed of more than one layer. Zoœcia with moderately thick walls, the apertures indented or floriform, a peculiarity due to the position of the very abundant acanthopores. These always encroach upon the visceral cavity. Rather large solid maculæ or monticules, composed of numerous abortive cells, completely filled by calcareous deposit, stud the surface at rythmical intervals. Diaphragms thin, few, sometimes wanting.

Type: *A. hirsuta* Ulrich. Range, Trenton ? and Cincinnati.

LEPTOTRYPA Ulrich.—Zoaria varying from thin incrustations to free forms of discoidal, spiral, or elongate conical shape; irregularly massive species occur also. Zoœcia polygonal, with thin walls, and a variable number of delicate diaphragms. Zoœcia walls appreciably thickened in the mature region. Acanthopores small, more or less numerous, but nearly always restricted to the angles of junction between the zoœcia. Mesopores wanting.

Type: *L. minima* Ulrich. Range, Trenton to Hamilton.

(?) DISCOTRYPA Ulrich.—Zoaria consisting of very thin, free or parasitic circular expansions. Surface with low broad monticules, or even. Zoœcia gradually decreasing in size from the center of the monticules, very regular in their arrangement, with thin walls, direct and generally hexagonal or rhomboidal apertures. Mesopores and acanthopores entirely absent.

Type: *D. elegans* Ulrich. Range, Cincinnati to Upper Helderberg.

Family DIPLOTRYPIDÆ n. fam.

Zoaria hemispheric, massive or ramose. Zoœcia forming comparatively large tubes of which the walls are more or less flexuous and mostly very thin. Mesopores and acanthopores present or wanting. Diaphragms very thin, developed at rather irregular intervals. No cystiphragms.

DIPLOTRYPA Nicholson.—Zoarium generally free and of hemispheric or discoid shape; in other cases massive, or forming thin crusts. Zoœcia with thin walls and rather irregularly distributed horizontal or oblique diaphragms. Acanthopores wanting in the typical species, but present in some of the others.

The genus as now understood, embraces at least three generically distinct sections, differing so much from each other as to suggest affinities with as many different families.

The typical section comprises, so far as known, only two species, the European type of the genus, *D. petropolitana* Pander, sp., and *D. westoni* Ulrich, a species lately described from rocks in Manitoba supposed to be of the age of the Cincinnati group.

Another section, typified by *D. infida* Ulr., from the Trenton shales of Minnesota, is closely related to *Prasopora*, while the Niagara species, *D. milleri* Ulr., is just as closely allied to *Callopo-*

rella. It is difficult to place *D. dubia* Ulr., and one or two other species, yet I am satisfied that they are not really congeneric with *D. petropolitana*.

Batostoma Ulrich.—Irregularly ramose, with a large basal expansion. Zoœcia with thin irregularly flexuous walls in the axial region, more or less thickened in the peripheral. Typically the walls are irregularly ovate and ring-like, with those of neighboring cells in contact only at limited points; the mesopores numerous, irregular in shape and size, and the acanthopores abundant and with a larger central cavity than usual. Species vary from these to forms with polygonal, thin-walled zoœcia and very few mesopores and acanthopores. Diaphragms strong, horizontal, incomplete in several species.

Type: *B. implicatum* Nicholson. Range, Trenton to Cincinnati.

Monotrypa Nicholson, (*Ptychonema* Hall).—Zoaria irregularly massive, discoid or subglobose, not divisible into mature and immature regions. Zoœcia comparatively large, prismatic, with walls very thin throughout and often undulating or wrinkled transversely; diaphragms remote. Both mesopores and acanthopores missing.

Type: *M. undulata* Nicholson. Range, Trenton to Lower Helderberg, perhaps also in Devonian and Carboniferous deposits.

Family Ceramoporidæ Ulrich.

Zoaria usually incrusting, at other times discoid, lamellate, massive, or forming more or less regular hollow branches; rarely bifoliate. Zoœcia with lunarium, the apertures usually oblique, of subtriangular, ovate, or, more rarely, polygonal form. The lunarium generally appearing at the surface as a prominent over-arching hood. In forms with direct apertures it appears as a slightly elevated portion of the margin, of crescentic form, with the ends projecting more or less into the apertures. Mesopores usually present, sometimes abundant, always irregular and without diaphragms. In the zoœcial tubes a few horizontal diaphragms are often present. Walls apparently minutely porous, composed of irregularly laminated tissue.

CERAMOPORA Hall.—Zoaria discoidal; free or attached by the center of the base to foreign bodies. Under surface with one or more layers of small, irregular, inter-communicating cells, which do not form tubes. Zoœcia large, oblique, imbricating, arranged in a radial manner around the depressed center, communicating with each other and the mesopores by means of remote perforations in their walls. Mesopores irregular, short, numerous at the center of the colony, decreasing in number toward the margin.

Type: *C. imbricata* Hall. Niagara group.

CERAMOPORELLA Ulrich.—Zoaria incrusting, becoming massive by superimposition of numerous thin layers. Zoœcial tubes short, the 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. In the fully matured state their apertures are closed by a thin membrane. Diaphragms occasionally present in the zoœcial tubes.

Type: *C. distincta* Ulrich. Range, Trenton to Niagara.?

CREPIPORA Ulrich.—Usually incrusting, sometimes lamellate or massive, with a wrinkled epitheca on the lower side; in one case forming regular hollow branches. Surface exhibiting, at subregular intervals, maculæ of mesopores, appearing as minutely porous or subsolid elevations or depressions. Zoœcia very little oblique, the apertures varying from rhomboidal to subpyriform. Lunarium well marked in perfect examples, but easily overlooked when a little worn; best shown in tangential sections. Mesopores usually restricted to the maculæ. Diaphragms are developed in moderate numbers.

Type: C. *simulans* Ulrich. Range, Trenton to Upper Silurian.

DIAMESOPORA Hall. (*Coeloclema* Ulrich).—Zoaria ramose, branches hollow, lined internally with a striated epitheca. Surface with or without maculæ. Zoœcia with rather thick walls, and sub-oval apertures. Peristome complete, but highest at the posterior side, making the aperture appear more oblique than it actually is. Lunarium scarcely distinguishable in tangential sections. Mesopores fairly numerous, rather equally distributed among the zoœcia. Diaphragms usually absent; occasionally one may be observed closing the apertures.

Type: *D. dichotoma* Hall. Range, Trenton to Lower Helderberg.

CHILOPORELLA Ulrich.—Zoaria rising up into flabellate fronds or compressed branches, from a greatly expanded heavy crust. Zoœcial tubes long; very thin-walled, large, and of irregular shape in the axial region. Walls much thickened near the surface. Apertures ovate, the lunarium conspicuously elevated. Mesopores numerous. Diaphragms few, generally absent.

Type: *C. flabellata* Ulrich. Cincinnati group.

ANOLOTICHIA n. gen.—Zoaria large, irregularly ramose or digitate. Zoœcia comparatively large, forming long sub-polygonal tubes, intersected by remote diaphragms. Walls thin, transversely lined in vertical sections. Apertures sub-oval, direct, with the lunarium, which occupies about two-fifths of the margin, elevated. Thin sections show the lunarium to have been traversed vertically by from three to six minute, closely tabulated tubes. Mesopores of irregular form, moderately abundant, rather equally distributed among the zoœcia.

Type: *A. ponderosa* Ulrich. Range, Trenton to Cincinnati.

SPATIOPORA Ulrich.—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 irregular apertures. Lunarium scarcely perceptible even in thin sections. Mesopores very few, usually absent. Interspaces often with large blunt spines (?acanthopores). Walls of zoœcia moderately thin, with the characteristic structure pertaining to the family.

Type: *S. aspera* Ulrich. Range, Cincinnati group; possibly to the Niagara.

Family FISTULIPORIDÆ Ulrich.

Zoaria massive, laminar, bifoliate or ramose. Zoœcia with a more or less developed "lunarium," causing many modifications in the form of the apertures; diaphragms horizontal. Interspaces occupied by vesicular tissue. Cystiphragms and acanthopores wanting; eccentrically perforated opercular covers close the perfect zoœcial aperture.

FISTULIPORA McCoy, *Lichenalia* Hall, *Thallostigma* Hall, *Didymopora* Ulrich.—Zoaria massive, lamellate, parasitic or free, with a wrinkled epitheca below; less commonly sub-ramose, the branches solid or hollow. Zoœcia subradially arranged about the surface maculæ, with ovoid, sub-triangular, or pyriform apertures, the variations being due to the degree in which the lunarium is developed; internally with thin walls and a small number of complete horizontal diaphragms. Interspaces smooth or granular, internally occupied by one or more series of vesicular cells.

Type: *Calamopora incrustans* Phillips (*Fistulipora minor* McCoy). Range, Lower Silurian to Carboniferous.

A section of the genus that ought, perhaps, to be separated, differs in having the zoœcial apertures circular and the lunarium obsolete.

Type: *F. communis* Ulrich.

ERIDOPORA Ulrich, *Pileotrypa* Hall (*pars*).—Zoaria thin, parasitic. Zoœcia with oblique, sub-triangular or ovoid apertures. Lunarium very prominent.

Type: *E. macrostoma* Ulrich. Range, Niagara to Coal Measures.

CHILOTRYPA Ulrich (*Cœlocaulis* Hall.)—Zoaria ramose, the branches with a small, irregularly contracting and expanding central tube. Zoœcia with the posterior portion of the wall thickest and strongly elevated hood-like, gradually thinning on the sides, becoming linear at the front; the aperture elliptical and oblique. Interstitial vesicles filled by a dense calcareous deposit near the surface. Diaphragms few or absent.

Type: *C. hispida* Ulrich. Range, Niagara to Coal Measures.

MEEKOPORA Ulrich.—Zoaria bifoliate, sometimes branching; the median laminæ thin, flexuous. Zoœcia not arranged in radial series around the solid maculæ, but with their oblique apertures directed towards the distal margin of the expansion. Lunarium moderate or obsolete. Zoœcial tubes oblique, the anterior walls thinnest and flexuous. Diaphragms numerous, often recurved. Oœcium a large oval cell, showing as a convex space with a small apical perforation.

Type: *M. eximia* Ulrich. Range, Keokuk, St. Louis and Chester.

STROTOPORA Ulrich.—Zoarium ramose, branches large, irregular, solid or hollow. Large abruptly spreading cells, which are supposed to represent oœcia, are distributed among the ordinary zoœcia. When well preserved they appear on the zoarial surface as strongly convex nodes, about 0.5 mm. in diameter, with an opening on one side.

In all other respects like *Fistulipora*.

Type: *S. foveolata* Ulrich. Range, Devonian to Lower Carboniferous.

LICHENOTRYPA Ulrich.—Zoaria thin, incrusting, with two distinct stages of development. In the first the colony resembles an ordinary species of *Fistulipora*, the zoœcia having subcircular apertures, surrounded by a peristome that is thickest and most elevated on the posterior side, the interspaces concave and smooth. As growth proceeds, the peristomes of the adjacent zoœcia are united by thin irregular walls, which traverse the interspaces and gradually form an elevated and very irregular net-work, with still greater elevations at numerous points in the shape of strong spines. Many of the zoœcia keep pace with the formation of this superficial structure, while others occupy the bottom of large cavities. Numerous subangular pores or vesicles are interspersed among the zoœcial apertures; the two kinds of cells not easily distinguished.

Type and only species known: *L. cavernosa* Ulrich. Middle Devonian.

BUSKOPORA Ulrich, (*Odontotrypa* Hall, *Glossotrypa* Hall, *Pileotrypa* Hall (*pars*).—Zoaria thin, lamellate, incrusting or free.

Zoœcia with sub-circular apertures and a faint peristome; posterior margin slightly more elevated than the anterior, with a strong bidenticulate process (lunarium), extending nearly half across the aperture, forming a ridge on the inner side of the zoœcia. The ridge is channelled along its inner termination. A variable number of small accessory cells, with elevated subcircular apertures, is present, also a few large tumid cells (ovicells?) occur among the ordinary zoœcia.

Type: *Fistulipora lunata* Rominger (*B. dentata* Ulrich.) Range, Devonian.

SELENOPORA Hall, *Favicella* Hall. Zoaria laminar or incrusting. Inter-zoœcial spaces occupied by two series of small vesicles, separated by strongly elevated walls, forming the borders of hexagonal concave spaces at whose centers the sub-circular zoœcia apertures are situated. The latter are surrounded by a thin peristome, but the lunarium is obsolete.

Type: *L. circincta* Hall. Range, Upper Helderberg and Hamilton.

? BOTRYLLOPORA Nicholson.—Zoaria simple or compound; when simple, consisting of small circular parasitic disks, the upper surface slightly convex, and marked by numerous radiating ridges which terminate before reaching the depressed center. Each ridge carries two rows of small contiguous rather thick-walled zoœcia. The depressed interspaces are smooth at the surface, but internally are occupied by comparatively large vesicles. When the zoarium is compound, it may consist of a large number of such disks and, by superimposition of layers of them, may eventually form small masses. The spaces between the disks are mainly occupied by very large vesicles, possibly of the nature of oœcia. Diaphragms, several times their diameter apart, cross the zoœcial tubes.

Type. *B. socialis* Nicholson. Hamilton group.

PINACOTRYPA n. gen.—Zoarium consisting of thin contorted expansions, with a wrinkled epitheca below. Zoœcia with subcircular apertures, a well developed granose peristome, thin walls and, so far as observed, no lunarium. Interspaces wide, occupied by a single series of very large angular mesopores, which never present the appearance of vesicular tissue. Diaphragms horizontal, few in the zoœcial tubes, numerous in the mesopores.

Type: *Fistulipora elegans* Rominger (*F. proporoides* Nich.). Range, Hamilton group.

Sub-order CRYPTOSTOMATA Vine.

Family CYSTODICTYONIDÆ Ulrich.

Zoaria consisting of two or three layers of cells grown together back to back, forming thin foliate expansions or triangular branches. Primitive cells semicordate or obovate-acuminate in outline, arranged in longitudinal series between vertical double plates. Primitive aperture subcircular, being somewhat truncated on the posterior side. As growth proceeds the aperture is drawn out shaft-like, forming a tubular vestibule, and the longitudinal plates become obsolete. Superficial aperture with peristome and more or less developed lunarium. Interspaces between zoœcia and vestibules occupied by vesicular tissue, the vesicles more or less completely filled with a minutely perforated calcareous deposit near the surface. Margin of zoarium sharp or rounded, and like the basal portion, non-celluliferous.

CYSTODICTYA Ulrich.—Zoaria ramose, bifoliate, the branches acutely elliptical in cross section, with sub-parallel, sharp, non-poriferous, striated, granulose, or smooth margins. Zoœcia apertures generally arranged in longitudinal series between ridges, sometimes in more pronounced oblique rows. Apertures sub-elliptical, partially closed in the fully matured condition with a more or less developed lunarium, that is always situated upon the side nearest to the margin of a branch. Interspaces finely striated, granulose, or smooth, and never with pits or cells, excepting when worn.

Type: *C. ocellata* Ulr., and *C. gilberti* Meek. Range, Upper Helderberg to Coal Measures.

COSCINIUM Keyserling, (*Coscinotrypa* Hall.—Zoaria composed of flattened branches, celluliferous on both sides, which inosculate at short intervals till there is produced a broad frond perforated at rythmical intervals by circular or elliptical fenestrules. In other respects like *Cystodictya.*

Type: *C. cyclops*, Keyserling. Range, Upper Helderberg to Carboniferous.

DICHOTRYPA n. gen.—Zoaria consisting of large, thin, bifoliate expansions. The surface with solid maculæ. Zoœcial structure in conformity with that given for the family.

Type: *D. foliata* Ulr. Range, Niagara to St. Louis.

ACTINOTRYPA n. gen.—Zoaria very much as in *Dichotrypa.* Zoœcia apertures showing the projecting ends of from eight to ten vertical septa-like ridges, that extend down on the inner side of the tubular vestibule nearly or quite to the primitive apertures.

Type and only known species *A. peculiaris* (*Fistulipora peculiaris* Rom.), of the Keokuk group.

TÆNIOPORA Nich.—Zoaria consisting of dichotomously divided branches as in *Cystodictya*, but differing from that genus in having a strongly elevated longitudinal central ridge on each face, causing the transverse section of the branch to be diamond shaped. The ridges may be obtusely angular, or sharp, thin and prominent. The zoœcia apertures are arranged in a pinnate manner or in longitudial rows, and increase in size outward.

Type: *T. penniformis* Nich. Hamilton group.

PRISMOPORA Hall.—Zoaria consisting of triangular branches di-or trichotomously divided at irregular intervals; sides equal or unequal, concave or flat, each celluliferous; margins sharp, straight or serrated, with a narrow solid border. In transverse section the zoœcia are seen to arise from internal laminæ, which radiate from the center to each angle, and divide the branches into three subequal triangular portions. Apertures varying in arrangment, frequently occupying the summits of small papillæ. Minute structures as given for the family.

Type: *P. triquetra* Hall. Range, Upper Helderberg to Coal Measures.

SCALARIPORA Hall.—Zoaria in every respect like those of *Prismopora*, excepting that the faces of the triangular branches are crossed by salient transverse ridges.

Type: *S. scalariformis* Hall. Range, Upper Helderberg to Hamilton.

EVACTINOPORA Meek and Worthen.—Zoaria free, consisting of four or more vertical leaves, which radiate from an imaginary axis so as to present in transverse section a star-shaped or cruciform outline. Rays thin, double, celluliferous on both faces, and free in the upper half; united, thick and non-poriferous in the basal portion; thickest and most dense at the outer and under edges. Zoœcia with subcircular apertures. Interspaces apparently solid at the surface, occupied by vesicular tissue internally. As growth proceeded, a gradually increasing deposit of minutely perforated calcareous laminæ covered the lower and older portions of the zoarium.

Type: *E. radiata* Meek and Worthen. Range, Burlington to Keokuk group.

GLYPTOPORA Ulrich, (*Ceramella* Hall.)—Zoaria consisting of thin bifoliate expansions, having both surfaces divided into larger or smaller cup-shaped cavities, by the bifurcation and coalescence of salient ridges; or of unilamellate bases, having the coalescing ridges of the upper surface developed to such a degree that they themselves form large expansions. The ridges in both cases consist of two layers of cells growing in opposite directions from a mesial lamina. The surfaces of the ridges and the bottom of the cups exhibit rather regularly distributed and more or less elongate solid maculæ, which, as they are commonly depressed below the level of the surface, have been called "dimples." Minute structure conforming with that given for the family.

Type: *G. plumosa* and *G. keyserlingi* Prout. Range, Burlington to Chester.

The following genera are placed here provisionally:

GONIOCLADIA Ethridge, Jr. Carboniferous of Great Britain.

CRISINELLA Hall. Lower Helderberg.

THAMNOTRYPA Hall. Lower Helderberg.

ACROGENIA Hall. Hamilton. Founded upon a remarkable species in which the zoarium is segmented very much as in *Dicranopora* Ulr.

COSCINELLA Hall. Hamilton.

Family RHINOPORIDÆ n. fam. (Provisional.)

RHINOPORA Hall.—Zoaria bifoliate; forming large undulating expansions, having the free lateral margins thickened and non-poriferous. Surface without maculæ or monticules, but when perfect, exhibiting slender rounded bifurcating ridges, which, when the zoarium is a little worn, appear as shallow grooves. The tubular structure thereby indicated is borne out by an examination of thin sections. These show further that they are crossed by rather remote partitions. Zoœcia apertures subcircular, occupying the summits of prominent papillæ, arranged in more or less regular intersecting lines. Mesopores small, about equal in number to the zoœcia, sometimes showing at the surface (?due to attrition). Large median tubuli between the mesial laminæ.

Type: *R. verrucosa* Hall. Range, Clinton and Niagara.

Family STICTOPORIDÆ Ulrich. (Emended).

Zoaria bifoliate, consisting of compressed branches, or leaf-like expansions. Primitive cells subquadrate, arranged in longitudinal series. Both primitive and superficial aperture elliptical or subcircular, sometimes a little truncated posteriorly when the superior hemiseptum is more than usually developed. Inferior septum wanting. Median tubuli present between the median laminæ, and the longitudinal rows of zoœcia vestibules. Mesopores absent, but vesicular tissue sometimes present.

STICTOPORA Hall, (*Rhinidictya* Ulrich).—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. Zoœcia apertures sub-circular 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.

Type: *S. fenestrata* Hall. Range, Chazy to Cincinnati, and perhaps also in Lower Helderberg.

EURYDICTYA n. gen.—Zoaria forming broad, simple or irregularly divided, bifoliate expansions, without non-poriferous parallel margins. Surface with more or less conspicuous, small, solid maculæ or monticules. Zoœcial structure very much as in *Stictopora*, the differences being of small importance and due to zoarial habit.

Type: *E. montifera* Ulr. Range, Trenton to Cincinnati.

DICRANOPORA Ulrich.—Zoaria jointed; segments ligulate, rarely simple, usually divided dichotomously at the upper end. Each extremity somewhat thickened and solid. Minute structure and arrangement of zoœcia apertures as in *Stictopora*.

Type: *D. internodia* Miller & Dyer. Range, Trenton to Cincinnati.

GONIOTRYPA Ulrich.—Like *Dicranopora* in all respects save that there is a prominent median ridge on each of the two faces of the double-leaved segments.

Type: *G. bilateralis* Ulrich. Cincinnati group.

EUSPILOPORA n. gen.—Zoaria consisting of small, flattened, irregularly divided branches. Zoœcia apertures subcircular or elliptical, arranged in four or more rows over the central portion of the branches between slightly elevated longitudinal ridges, bearing numerous, small nodes. At brief intervals, occuring alternately on each side of the branch, there are several short rows of apertures directed obliquely upward and outward from the central rows, extending nearly to the sharp margins. Between these lateral rows the margin of the frond is more or less indented, but a wide depressed non-poriferous space remains. This is covered with exceedingly fine granulose striæ. Thin sections show that between the ends of the zoœcia there is a vertical series of shallow lenticular vesicles, separated from each other by a thick layer of tissue. All the remaining interspaces are traversed vertically by exceedingly numerous minute tubuli.

Type: *E. serrata* Ulrich. Range, Hamilton group.

PACHYDICTYA Ulrich.—Zoaria varying from parallel margined narrow branches to large undulating expansions. The edges are acute and have a non-celluliferous border. In the larger species the surface exhibits solid granulose maculæ. Zoœcia rising rather abruptly from the mesial laminæ, near which they have very thin walls, are broad elliptical or subquadrate in outline, arranged in longitudinal series and partially separated from each other by small vesicles. Toward the surface their walls are thickened, ring-like, and usually completely isolated, and the interspaces solid. Median tubuli well developed between the mesial laminæ, and in one or two rows between the zoœcia. Apertures plain or with slight peristome. Diaphragms cross the zoœcia tubes.

Type: *P. robusta* Ulr. Range, Trenton to Lower Helderberg.

PHYLLODICTYA Ulrich.—Zoaria leaf-like, or consisting of irregular broad branches. Zoœcia tubular, the prostrate portion long; apertures circular, slightly oblique, with the posterior margin elevated. Interspaces wide, solid, granulose, traversed vertically by numerous minute tubuli. A few diaphragms present.

Type: *P. frondosa* Ulr. Range, Trenton.

Family PTILODICTYONIDÆ Zittel.

Zoaria segmented or continuous, bifoliate. Zoœcia sub-tubular, the primitive cell more or less elongated, subquadrate, rhombic, or hexagonal in outline, with thin walls. Both superior and inferior hemisepta generally present. Vestibular portion with thick and often ring-like walls, the central region between the cavities usually of conspicuously lighter or darker color than the rest. When wide the region usually appears transversely lined; at other times occupied by untabulated mesopores. Median tubuli wanting.

PTILODICTYA Lonsdale. (*Escharopora* Hall, *Heterodictya* Nich.)—Zoaria segmented, consisting of a small, radially striated basal expansion which is attached to foreign bodies, and has at the center of the upper surface a socket for articulation with the sub-solid extremity of the erect and unjointed frond. Frond commonly lanceolate or falciform, sometimes a broad undulating expansion, at other times dichotomously branched with the margins parallel. Proximal extremity longitudinally striated, pointed or wedge-shaped. Lateral margins of frond acute, non-celluliferous, smooth or obliquely striated. Small monticules usually present in the large species. Zoœcia with subcircular or elliptical superficial apertures, surrounded by a sloping area of quadrate, rhombic or hexagonal outline. Apertures arranged in a plumose manner, with longitudinal series in the center and, diverging from these on each side, oblique lateral rows; or simply in regular diagonally intersecting series. Both hemisepta usually well developed.

Type: *P. lanceolata* Goldf. Range, Trenton to Upper Helderberg.

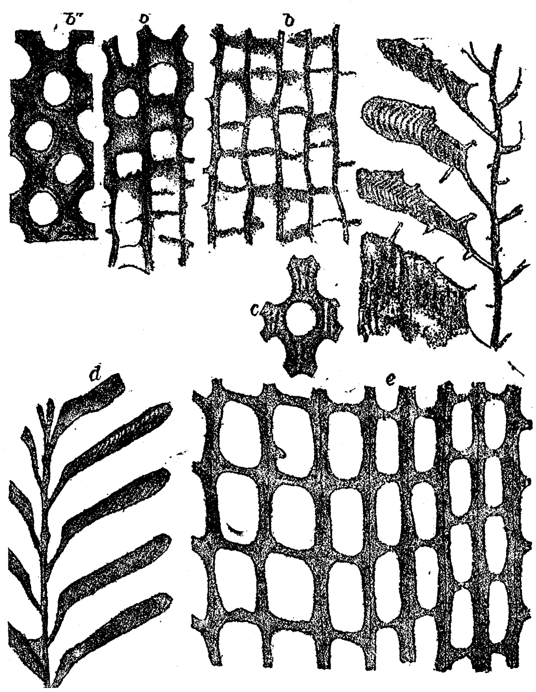

Fig. 11. Sections of *Ptilodictya*. All the figures are magnified x25.—*a*. Portion of a vertical section of *Ptilodictya magnifica* S. A. Miller, showing several zoœcia with hemisepta;—*b*, *b'*, and *b''*, three portions of a tangential section of same, showing structure of zoarium at various depths below the surface:—*c*, zoœcium of same sectioned just beneath the aperture, and showing slightly different structure from what is seen in *b*.''—*d*, vertical section of *Ptilodictya lanceolata* Goldf., from Gotland;—*e*, tangential section of the American representative of the species; Clinton gr., Dayton, Ohio. (*P. expansa* Hall, Ind. Geol. Sur., vol. 12, 1882, not *Phænopora expansa* Hall and Whitfield, Pal. Ohio, vol. II, 1875).

CLATHROPORA Hall.—Zoaria composed of anastomosing branches, forming a regular net-work with round fenestrules. Minute structure essentially the same as in *Ptilodictya*.

Type: *C. frondosa* Hall. Range (?) Trenton to Upper Helderberg.

PHÆNOPORA Hall.—Zoaria as in *Ptilodictya*, from which they differ in having two mesopores between the ends of the zooecia apertures.

Type: *P. explanata* Hall. Range, Cincinnati to Lower Helderberg.

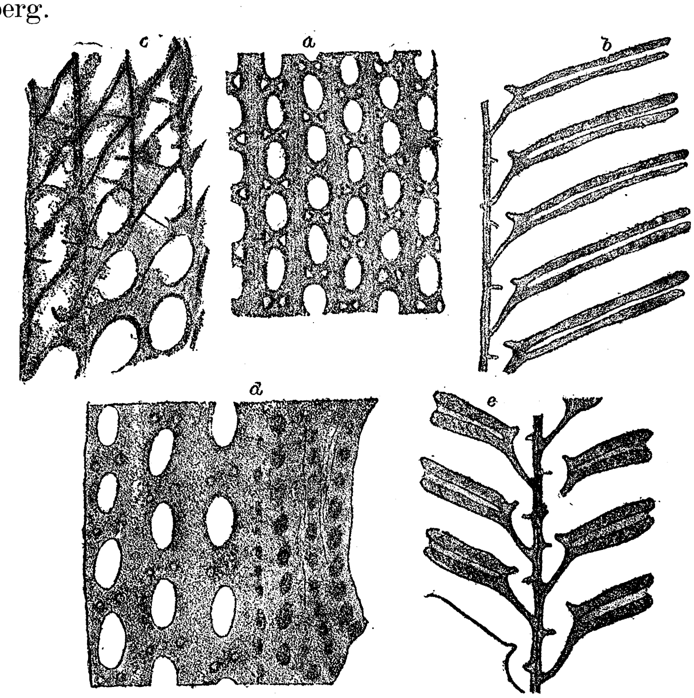

Fig. 12. Sections illustrating the internal structure of *Phænopora;* all x25.—*a*, tangential section of *P. constellata* Hall, showing structure of zoarium just beneath the surface;—*b*, half of a vertical section of same;—*c*, deep tangential section of *P. expansa* H. & W., showing structure of zoarium just above the median laminæ;—*d*, tangential section of *P. lindströmi* n. sp., showing the pitted margin and three rows of zoœcia;—*e*, vertical section of same.*

* *Phænopora lindströmi* is from the Upper Silurian deposits of Gotland. It grows into narrow, parallel-margined, compressed branches, about 1.5 mm., thick, 3.8 to 4.5 mm. wide, bifurcating at intervals of 10 mm. more or less. Margins wide, rather sharp, with several rows of small pits. Zoœcia apertures elliptical, about 0.19 mm. long, arranged in 9 to 12 longitudinal series, 14 in 5 mm. Between the ends of the apertures are the usual two mesopores.

I am indebted to the eminent palæontologist, Dr. Gustav Lindström, of Stockholm, Sweden, for an excellent example.

GRAPTODICTYA Ulrich.—Zoaria rising from a pointed articulating base into continuous dichotomously divided narrow fronds. Zoœcia with subcircular aperture, surrounded by a low peristome subpolygonal in outline. Interspaces depressed, generally linear, sometimes with one or two fine tortuous elevated lines; vertically lined in longitudinal sections, but with the lines interrupted. Median laminæ straight in transverse sections.

Type; *G. perelegans* Ulrich. Range, Trenton to Cincinnati.

ARTHROPORA Ulrich.—Zoaria bushy, spread in a plane, composed of numerous segments; joints sometimes simple, usually with several short lateral branchlets, some of which may be tipped for articulation with succeeding segments. Zoœcia with elliptical or subpyriform apertures and elevated margins. Interspaces with one or more vermicular striæ. Apertures, when perfect, closed by centrally perforated opercular structures. Median laminæ zigzag in transverse sections.

Type: *Stictopora shafferi* Meek. Range, Trenton and Cincinnati.

TÆNIODICTYA n. gen.—Zoaria growing from a basal expansion into dichotomously divided narrow branches or broad fronds. Zoœcial structure very much as in some species of *Ptilodictya* (*P. pavonia* D'Orb.). Apertures elliptical or subcircular, surrounded by a sloping area. Interspaces ridge-like. Both "hemisepta" present.

Type: *T. ramulosa* n. sp. Range, upper Helderberg to St. Louis.

PHILOTRYPA n. gen.—Zoaria forming large ramose expansions. Zoœcial tubes and apertures very oblique. At the upper extremity of the acutely ovate aperture there is a small cell which is best seen in tangential sections. Surface with irregular, longitudinally channelled spots.

Type and only known species: *P. obliquata* n. sp. Cincinnati group.

STICTOTRYPA n. gen.—Zoaria consisting of dichotomously divided, narrow, compressed branches. Zoœcial apertures circular or elliptical, surrounded by a distinct, evenly elevated peristome. Interspaces flat or concave, composed of horizontally laminated solid tissue.

Type: *Stictopora similis* Hall. Range, Trenton to Niagara.

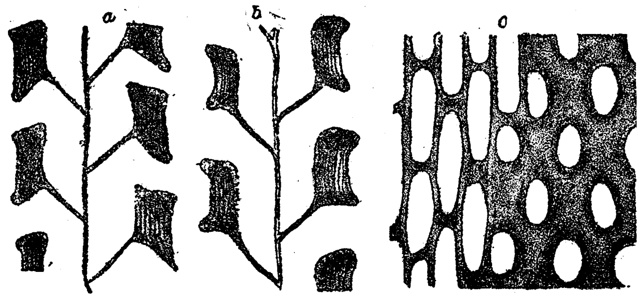

Fig. 13.—*a*, vertical section of *Stictotrypa punctipora* Hall (sp.).—*b*, vertical section of *Stictotrypa similis* Hall (sp.).—*c*, tangential section of same. All x25.

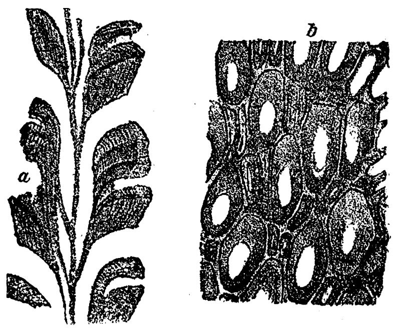

Fig. 14. *a*. tangential section of *Stictoporella interstincta* Ul. (Cin. gr.); *b*, vertical section of same.

STICTOPORELLA Ulrich.—Zoaria branching, cribrose, or leaflike. Zoœcia with the primitive portion tubular and unusually long. Superior hemisepta wanting; the inferior ones sometimes present. Apertures placed at the bottom of a wide sloping area. More or less numerous thick-walled and untabulated mesopores occur between the zoœcia apertures and line the zoarial margin. In the frondose species they also form clusters. Tangential sections show that both the zoœcia and mesopores are separated from each other by a sharply defined line.

Type: *S. interstincta* Ulrich. Range, Trenton to (?) Chester.

INTRAPORA Hall, (*Cosinella* Hall.)—Zoaria cribrose, branching, or sub-frondose. Zoœcia with moderately thin walls, which are not sharply distinguished from those of the numerous tabulated mesopores which occupy the interspaces. Apertures subcircular, without area but enclosed by faintly elevated peristomes. A short distance below the plane of the zoœcia apertures perfect specimens show a perforated diaphragm. Mesopores usually open at the surface, but sometimes completely closed by a deposit of horizontally laminated calcareous matter.

Type: *I. puteolata* Hall. Range, Devonian.

Family FENESTELLIDÆ King.

Zoaria forming reticulate expansions, celluliferous on one side only, composed of rigid branches united to each other by regular non-poriferous bars called dissepiments; or they may be sinuous and anastomose; or even remain free. Primitive portion of zoœcia of oblong quadrate or hexagonal outline. Superior hemiseptum usually present, the inferior one less frequently. Primitive aperture semi-elliptical, being truncated at the posterior side. Superficial apertures rounded, with peristome, and, in the perfect state, closed by centrally perforated opercula.

FENESTELLA Lonsdale.—Zoaria flabellate to infundibuliform, poriferous on the inside (always?); branches nearly straight, and connected with each other at rhythmical intervals by non-poriferous dissepiments. Zoœcia in two rows, separated by a more or less developed median keel.

Accepted type: *F. plebeia* McCoy. Range, Cincinnati to Permian.

SEMICOSCINIUM Prout, (*Carinopora* Nicholson).—Zoaria funnel-shaped, poriferous on the outer side. Dissepiments wide, very short, the branches appearing on the non-poriferous side to anastomose. Here, also, the fenestrules are sub-rhomboidal or rounded. Zoœcia in two ranges. Median keel very high and more or less expanded at the summit.

Type: *S. rhomboideum* Prout. Range, Niagara to Hamilton.

FENESTRAPORA Hall.—In all respects like *Semicoscinium*, excepting that the reverse of the zoarium and the expanded summits of the carinæ bear large pores or pits.

Type: *F. biperforata* Hall. Range, Upper Helderberg and Hamilton.

ISOTRYPA Hall (emended).—Zoaria infundibuliform; branches connected by dissepiments. Keel at first very thin, then abruptly expanded; at intervals corresponding to the true dissepiments, the thickened summits are connected by strong processes, giving to the superstructure an appearance very much like that of the reverse face of the frond. Zoœcia in two ranges.

Type: *I. conjunctiva* Hall. Range, Niagara to Hamilton.

UNITRYPA Hall.—Zoaria infundibuliform; zoœcia in two ranges. Keels as in *Semicoscinium*, but with their summits connected by sub-imbricating transverse bars or plates, which may be as numerous as the zoœcia, or only two to each fenestrule.

Type: *U. lata* Hall. Range, Lower Helderberg to Hamilton.

HEMITRYPA Phillips.—Zoaria funnel-shaped or undulating foliar expansions; branches rigid. Zoœcia in two ranges, their apertures separated by a moderately developed keel. The latter is elevated at regular intervals into small pillars, which, when the superstructure they support is worn away, appear as spine-like prominences. The superstructure consists of straight or zigzag longitudinal bars, of which one is placed over each branch upon the row of pillars, and another usually somewhat thinner, suspended midway between the branches. These bars are then connected by transverse processes, so as to leave regular, small, generally hexagonal openings, corresponding in number and position with the zoœcial apertures beneath them.

Type: *H. oculata* Phillips. Range, Clinton to St. Louis.

HELICOPORA Claypole.—Zoaria spiral, the inner edge thickened and non-poriferous, without, however, forming a solid central axis. Other characters as in *Fenestella*.

Type: *H. latispiralis* Claypole. Range, Niagara and Devonian.

ARCHIMEDES Lesueur. Zoaria like those of *Helicopora*, but differing in having a solid central axis.

Type: *A. wortheni* Hall. Range, Keokuk to Chester.

LYROPORA Hall.—Zoaria flabellate, the fenestrated portion spread between two strong, non-celluliferous, diverging supports. Zoœcia in from two to five rows. Median keel obsolete.

Type: *L. quincuncialis* Hall. Range, Burlington to Chester.

FENESTRALIA Prout.—Zoaria strong, with two rows of cells on each side of the median keel. In other respects like *Polypora*.

Type and only known species: *F. sancti-ludovici* Prout. St. Louis group.

POLYPORA McCoy.—Zoaria in most respects like *Fenestella*, but differing in having from two to six or even eight rows of cells, and in wanting the characteristic median keel. The latter is sometimes represented by a row of strong tubercules. Such species approach *Fenestralia* Prout.

Original type: *P. dendroides* McCoy; accepted type: *P. schumardi* Prout. Range, Niagara to Coal Measures.

THAMNISCUS King.—Zoaria differing from those of *Polypora*, in wanting the dissepiments entirely, or in having them recur at very irregular and much longer intervals; besides, the branches bifurcate more freely.

Type: *T. dubius* Schlotheim sp. Range Niagara to Permian.

PHYLLOPORA King.—Zoaria infundibuliform, consisting of anastomosing branches, which form a regular, round-meshed network. Zoœcia in two or more rows.

Type: *P. ehrenbergi* King. Range, Devonian to Permian.

(?) CRYPTOPORA Nicholson. May be the same as *Hemitrypa*.

PTILOPORINA Hall.

PTILOPORELLA Hall.

(?) LOCULIPORA Hall.

Family ACANTHOCLADIIDÆ Zittel (Ulrich emend).

Zoaria poriferous on one side only, dendroid, pinnate, or forming fenestrated expansions; consisting of strong central stems and numerous lateral branches which proceed from their opposite margins. The lateral branches are free, or may unite (in the fenestrated genera) with those of the adjacent branches. Non-poriferous dissepiments absent. Zoœcia and minute characters as in the FENESTELLIDÆ.

PINNATOPORA Vine. (*Glauconome* of authors) —Zoaria small and delicate. Lateral branches short, free. Cells in two rows, one on each side of a moderately developed median keel, which is fainter or wanting on the lateral branches.

Type: *Glauconome elegans* Y. & Y. Range, Lower Helderberg to Upper Coal Measures.

SEPTOPORA Prout.—Zoaria fenestrated, flabellate or leaf-like. Primary branches numerous, increasing by bifurcation or interpolation, and so arranged that the smaller lateral branches which proceed from their opposite margins unite with those of the adjacent branches. Reverse, or non-celluliferous side usually with fine striæ, and a variable number of scattered dimorphic pores. Celluliferous side, with two rows of zoœcia arranged as in *Pinnatopora*. Apertures large.

Type: *S. cestriensis* Prout. Range, Chester, Lower and Upper Coal Measures.

ACANTHOCLADIA King.—Zoaria like those of *Pinnatopora*, but larger and with three or more rows of cells. Between these the surface is elevated into small longitudinal ridges or series of tubercles.

Type: *A. anceps* Schlotheim. Range, Upper Coal Measures to Permian.

SYNOCLADIA King.—This genus differs from *Acanthocladia* in the same manner as *Septopora* does from *Pinnatopora*, in having the lateral branches of adjacent stems unite with each other, thereby forming of the whole a fenestrated frond.

Type: *S. virgulacea* King. Permian.

DIPLOPORA Young & Young. Zoaria consisting of very slender straight stems, which throw off a few lateral branches of equal dimensions; Cells in two rows. Median keel moderately developed.

Type: *D. marginalis* Y. & Y. Range, Chester and Coal Measures.

PTILOPORA McCoy. — Zoaria pinnate, the median branch stronger, particularly on the reverse, than the oblique lateral branches. The latter are united to each other at frequent intervals by non-poriferous dissepiments. Zoœcia in two ranges.

(?) Type: *Retepora flustriformis* Phillips (*P. prouti* Hall, is a typical form.) Range, Hamilton to St. Louis.

Icthyorachis McCoy, *Penniretepora* D'Orb., and *Ramipora* Toula probably belong here.

Family SPHRAGIOPORIDÆ n. fam.

Zoaria parasitic; zoœcia of the same type as in the FENESTELLIDÆ.

SPHRAGIOPORA n. gen.—Zoaria parasitic, forming very small, sub-hemispheric patches on foreign bodies. Zoœcia with circular apertures and slight peristome, arranged in a sub-radial manner, in single or double rows.

Type: *S. parasitica* n. sp. Range. Chester to Upper Coal Measures.

Family Phylloporinidæ n. fam.

Zoaria retiform and consisting of anastomosing branches; at other times dichotomously branched; celluliferous on one side, the other finely striated. Zoœcia tubular, rather long, often with diaphragms. Without hemisepta.

Phylloporina n. gen.—Zoaria consisting of somewhat irregularly anastomosing branches, with from two to eight ranges of zoœcia on the celluliferous side. Reverse convex, longitudinally striated. Zoœcia tubular, with or without diaphragms. Mesopores generally present, sometimes numerous, always closed at the surface; with diaphragms.

Types: *Retepora trentonensis* Nich., and *R. asperato-striata* Hall. Range, Chazy to Niagara.

Chainodictyon Fœrste.—Much like the preceding but the zoœcia somewhat shorter. Mesopores and diaphragms wanting. Reverse flattened, concentrically undulated or striated.

Type: *C. laxum* Fœrste. Coal Measures.

Drymotrypa n. gen.—Zoaria branching dichotomously at frequent intervals. Reverse longitudinally striated. Zoœcia in several ranges, tubular, thick-walled in tangential sections, springing from a thin double plate, beneath which a number of vesicles (? aborted zoœcia) are present. Superficial apertures angular, becoming oval a short distance within on account of the thickening of the walls.

Type: *Retepora diffusa* Hall, (Pal. N. Y. vol. II, p. 160). Niagara group.

The genus will also include *Thamniscus cisseis* Hall, (Lower Held.) and *T. niagarensis* Hall. A fourth species from the Trenton of Canada not yet described, I propose to name *Drymotrypa dichotoma*.*

**Drymotrypa dichotoma* n. sp. Pl. LIII, fig. 6.—Zoarium spreading in a plane, consisting of frequently branching lax ramulets, one side of which is finely striated, the other bearing the mouths of four ranges of zoœcia; intervals between bifurcations

Family ARTHROSTYLIDÆ Ulrich.

Zoaria articulated, ramose, consisting of numerous sub-cylindrical segments, or, if dichotomously divided, of continuous branches, which articulate with a slightly expanded attached base. Zoœcia sub-tubular, more or less oblique, radially arranged around a central axis, opening on all sides of the segments; more rarely, one side is non-celluliferous and striated longitudinally.

ARTHROSTYLUS. n. gen.*—Zoaria dichotomously divided, composed of numerous slender equal segments, joined to each other by terminal articulation; poriferous on one side only; opposite side longitudinally striated. Zoœcia arranged in three or more rows, between carinæ.

Type: *Arthronema tenue* Ulrich ("Amer. Pal. Bry.") Range, Trenton and Cincinnati.

ARTHROCLEMA Billings.—Zoarium articulated, composed of numerous sub-cylindrial segments arranged in a pinnate manner, those forming the central stem the largest. Each of the primary segments with one or two sockets on each side for articulation with the smaller secondary segments; these again in like manner articulate with still more slender tertiary segments. Celluliferous on all sides. Zoœcia somewhat oblique, with nearly direct oval apertures, arranged between elevated carinæ. A diaphragm may intersect the tube at about the middle of its length.

Type: A. *pulchellum* Billings. Range, Trenton and Cincinnati.

SCEPTROPORA n. gen.—Segments club-shaped, the lower half striated, non-celluliferous, the extremity bulbous; upper half expanded, the center of the top with a large socket. Zoœcia tubular, arranged between vertical lines; apertures sub-ovate.

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about 1.5 mm.; width of branches about 0.5 mm. Zoœcial tubes arranged bilaterally, two on each side of a vertical lamina, not observed at the surface. Celluliferous face not seen. Zoœcia (as shown by tangential sections) tubular, with broadly oval apertures, their longer diameter 0.12 mm., about four in one mm. Walls thin within, rapidly thickening toward the aperture. One or two diaphragms in most of the tubes.

This interesting species I obtained from the Peter Redpath Museum of Montreal, Canada, through the kindness of Sir Wm. Dawson. The specimens were collected by Mr. T. Curry, at Montreal, from the Trenton limestone.

* This name is proposed instead of *Arthronema* which was pre-occupied by Schscholtz.

Type: *S. facula* n. sp. Cincinnati group. Manitoba, and Wilmington, Ill.

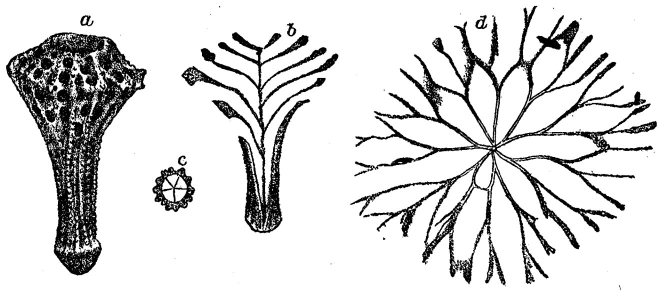

Fig. 15. *Sceptropora facula* n. sp. Cincinnati group, Stony Mountain, Manitoba.*—*a.* A segment of the average size and appearance.—*b.* A vertical section, showing tubular zoœcia and central axis.—*c.* Transverse section of lower half of a segment.—*d.* Transverse section of expanded portion of a very large segment. All magnified to 18 diameters.

The segments vary in length from less than one mm. to nearly two mm.; the width of the expanded top from 0.7 mm. to 2.0 mm. I am indebted to Prof. J. F. Whiteaves, the palæontologist to the Geological and Natural History Survey of Canada for the opportunity of describing this unique species.

HELOPORA Hall.—Zoaria composed of subequal cylindrical segments, articulating terminally, poriferous all around. Zoœcial tubes somewhat oblique, straight or geniculated. Apertures sub-oval, arranged between slightly elevated lines, or in diagonally intersecting series. Inferior border often prominent, sometimes also bearing an acanthopore.

Type: *H. fragilis* Hall. Range, Trenton to Niagara.

NEMATOPORA n. gen.—Zoaria very slender, ramose, continuous above the pointed basal extremity. Zoœcia sub-tubular, short, arranged in a radial manner around one or two minute axial tubes. Apertures ovate or sub-circular, with peristome, generally arranged between longitudinal ridges. One or two diaphragms occasionally present.

Type: *N. quadrata* n. sp. Trenton group. Range, Trenton to Niagara.

Family RHABDOMESONTIDÆ Vine.

Zoaria ramose, solid, or with an axial tube. Zoœcia with the primitive portion tubular; hemisepta usually developed. Aper-

* I have lately collected this species at Wilmington, Ill., a locality that has proven exceedingly rich in Bryozoa. Also at Savannah, Ill.

tures regularly arranged, oval or circular, placed at the bottom of a sloping area, rhombic or hexagonal in outline, or between straight or flexuous longitudinal ridges. Acanthopores and smaller spines generally present, but mesopores are absent.

RHOMBOPORA Meek, (*Orthopora* Hall.)—Zoaria slender, ramose, solid. Zoœcia with the vestibular or outer portion thick-walled. Apertures arranged regularly in diagonally intersecting or longitudinal lines. Strong acanthopores often present at the angles of junction and more numerous, smaller spines, generally occupy the summit of the ridge-like interspaces between the sub-elliptical apertures. Diaphragms sometimes present in the axial region.

Type: *R. lepidodendroides* Meek. Range, Niagara to Upper Coal Measures.

RHABDOMESON Young and Young.—This genus differs from *Rhombopora* only in having a slender axial tube, to which the proximal ends of the zoœcia are attached.

Type: *Millepora gracilis* Phillips. Carboniferous. This genus is not known from American deposits.

CŒLOCONUS n. gen.—Zoaria simple, hollow, expanding gradually from the striated and sub-acute basal extremity; substance thin. External characters of zoœcia as in *Rhombopora*; primitive portion short. Hemisepta well developed.

Type: *C. rhombicus* n. sp. Range, St. Louis to Chester.

NEMATAXIS Hall. Upper Helderberg and Hamilton.

ACANTHOCLEMA Hall (*pars.*) Upper Helderberg to Warsaw.

BACTROPORA Hall.—Zoaria simple, unbranched, the lower extremity pointed. In other respects like *Rhombopora.*

Type: *B. granistriata* Hall. Upper Helderberg to Keokuk.

(?) TROPIDOPORA Hall. Upper Helderberg.

Family STREBLOTRYPIDÆ Ulrich.

Zoaria variable. Zoœcia with the primitive portion sub-tubular or tubular; apertures sub-circular, often truncated posteriorly, surrounded by a slightly elevated rim. Front, or outer surface of cell back of the aperture, simply depressed, or with from two to twelve or more small pits. Diaphragms wanting.

STREBLOTRYPA Ulrich.—Zoaria ramose, slender, solid. Zoœcia radiating from an imaginary axis, their primitive portion long, tubular; or from a linear axis when they are somewhat shorter. Inferior hemisepta best developed, situated rather far down. Apertures regularly elliptical, or somewhat truncated at the posterior margin, surrounded by a slight peristome and, within this, sometimes a narrow sloping area; arranged usually in rather regular longitudinal series. Just back of the aperture, occupying the depressed front of the cell, there are from one to twelve or more small pits, which, when numerous, are arranged in two or three rows. Very small acanthopores occasionally present.

Type: *S. nicklesi* n. sp. Range, Hamilton to Chester.

WORTHENOPORA n. gen.—Zoaria bifoliate, branching or palmate. Zoœcia very regularly arranged, sub-tubular, or rather, elongate rhomboidal, with the aperture semi-elliptical. On the surface the line of junction between the cells is marked by an elevated ridge. The truncated posterior margin of the aperture is raised into a less strong transverse bar. The elongate triangular depressed front appears perfectly plain.

Type: *W. spinosa* n. sp. Range, Keokuk to St. Louis.

CYCLOPORA Prout.—Zoaria unilaminar, parasitic or free. Primitive portion of zoœcia, sub-tubular. Apertures sub-circular or somewhat truncated posteriorly, surrounded by a moderate, granose or smooth, peristome; arrangement various. When regularly developed there is a large oblong more or less shallow depression between each four adjacent zoœcia. With a less regular development, this space may be divided into two smaller ones; or it may appear that the apertures are separated by unequal and irregularly situated depressions. With growth these interspaces are drawn out into tabulated mesopores. (Pl. LXVIII, fig. 3f.) Hemisepta very little developed.

Type: *C. fungia* Prout. Range, Keokuk and Warsaw beds.

PROUTELLA n. gen.—Zoarium discoid, thin, free, the lower surface convex and lined with a concentrically wrinkled epitheca. Primary zoœcia sub-tubular, the succeeding ones shorter, all rather thin-walled. Aperture broad-elliptical, surrounded by a very narrow sloping area, hexagonal in outline; when perfect, with a depressed delicate calcareous plate, that closes a little less than two-thirds of the opening, the orifice left being sub-triangular in form, without thickened margins, and situated at the anterior side. With age, a second, third and more layers of zoœcia are developed directly over the first, so that they gradually form a zoœcial tube seemingly having the cavity intersected by incomplete diaphragms. These appear to spring from the posterior wall and extend about one-half the distance across.

Type and only known species: *Cyclopora discoidea* Prout. Keokuk group.

? CYCLOPORELLA n. gen.—Zoarium a thin discoidal expansion. Zoœcia sub-tubular, with a succession of superior hemisepta in the vestibular portion. Irregular mesopores abundant. Acanthopores of large size, numerous.

Type: *C. spinifera* Ulrich. Keokuk group.

Family HELIOTRYPIDÆ Ulrich (Provisional.)

HELIOTRYPA Ulrich.—Zoarium bifoliate. Primitive portion of zoœcia sub-tubular, thin-walled and prostrate upon the median laminæ. Superior hemiseptum moderately developed. Vestibular or outer portion of the zoœcia thick-walled, the walls traversed obliquely by radially arranged minute tubuli. Interspaces of variable width, occupied by numerous, irregular, rounded, thick-walled and tabulated mesopores, which are also aggregated at intervals to form maculæ. Walls of mesopores and zoœcia vestibules amalgamated. Median tubuli present between the median laminæ. Superficial apertures circular, surrounded by a sloping area. Interspaces flat between the mesopore apertures.

Type and only known species: *H. bifolia* Ulrich. Chester group.

DESCRIPTIONS OF SPECIES.

PROTOCRISINA Ulrich.

(For generic diagnosis see page 369).

PROTOCRISINA EXIGUA Ulrich.*

Pl. XXIX, fig. 4-4*c*, and Pl. LIII, fig. 11-11*e*.

Zoarium ramose; branches slender 0.6 mm. wide, 0.3 to 0.45 mm. thick, dividing dichotomously at a very acute angle at intervals varying from two to seven mm. Celluliferous side strongly convex, smooth, with four, occasionally only three, series of zoœcia. Reverse faintly convex, flattened or slightly concave in the central part, finely striate, the striæ often minutely granulose. Zoœcia subtubular, thin-walled within, with prominent tubular mouths. Apertures subcircular, 0.09 mm. in diameter, five or five and one-half in two mm. vertically; arranged in oblique rows. A small number of circular pores, 0.04 mm. in diameter are scattered over both the reverse and celluliferous faces.

Position and locality.—This species is rare at Wilmington, Ill., where it is associated with typical Cincinnati group fossils. It is more common and in a better state of preservation in Trenton group strata at Montreal, Canada, and Trenton Falls, N. Y.

*This form can scarcely be regarded as more than a variety of a rather common Trenton group species, in New York and Canada, where it is generally identified with the form to which Hall applied the name of *Gorgonia ? perantiqua* (Pal. N. Y., vol. I,). This identifica'ion is probably erroneous since neither the figures nor the description agree with the specimens. These consist of numerous rigid, remotely bifurcating branches, which are spread upon a plane about their own width apart, with four rows of pores. Hall says the branches are "lax" and carry two laterally opening rows of cells. Under these circumstances it seems to me better to propose a new name for the species than to perpetuate what is obviously an error.

PHACELOPORA Ulrich.

(For generic diagnosis see page 368.)

PHACELOPORA PERTENUIS Ulrich.

Pl. XXIX, fig. 1-1*c*.

Zoarium articulated; exceedingly slender, consisting of numerous, elongate conical segments, arranged in linear series. Often two segments are developed instead of one, when the zoarium is dichotomously branched. Zoœcia tubular, compressed conical, suboval in transverse section, with an average width of 0.12 mm., arranged in pairs, each pair constituting a segment; apertures contracted, circular, about 0.06 mm. in diameter. Sutures between zoœcial tubes more sharply impressed on the anterior side than on the posterior where the minute axial tube is situated. Segments 0.6 to 0.8 mm. long, 8-shaped in cross-section just below the apertures; here the lateral diameter is from 0.2 to 0.25 mm. and the smaller about 0.15 mm., while at the proximal extremity of each segment the diameter is only 0.07 mm. Segments are developed from the minute axial tube.

This very interesting bryozoan is so unique, that no comparisons are required. Its thread-like zoarium is readily overlooked.

Position and locality:—Upper beds of the Trenton group. Thebes, Ill. Rather rare, associated with several species of *Nematopora* and Crinoids.

PHACELOPORA CONSTRICTA Ulrich.

Pl. XXIX, fig. 2.

Of this species I have seen only the fragment figured. This consists of five short segments, having each the appearance of being set into the expanded upper end of the one preceding it. The segments vary slightly in length, but do not exceed 0.3 mm.; the diameter expands from about 0.13 mm. below, to 0.25 mm., or a little less, at the apertures. Each is composed of five (possibly six) subcylindrical zoœcial tubes, the sutures being sharply impressed, and most of the slightly contracted circular apertures apparently closed by a convex lid. The diameter of the aperture is about 0.07 mm., that of the zoœcial tube just beneath the aperture a little less than 0.1 mm.

Position and locality:—The specimen came from the upper beds of the Trenton group in Central Kentucky.

MONTICULIPORA d'Orbigny, 1849.

(Prod. Pol., p. 25.)

(For generic diagnosis see page 370.)

The genus *Monticulipora* was founded by the distinguished French naturalist, d'Orbigny, for the reception of four characteristic species of the Lower Silurian rocks about Cincinnati, Ohio. Of these, *M. mammulata*, being the first species to follow the generic diagnosis, is universally regarded as the type. The original descriptions are so meagre that palæontologists are compelled to rely upon Edwards and Haime's identification of the species. These authors give good figures of three of the species, and of the fourth (*M. filiosa*) a description only. As all four of the species are common and marked by easily recognized external characters, collectors have had little difficulty in identifying them.

The genus, as defined and used by me, is founded upon *M. mammulata* and does not include any of the other species described by d'Orbigny. His *M. ramosa* belongs to *Callopora*, *M. filiosa* to *Leptotrypa*, or, possibly, *Monotrypa*; and *M. frondosa* to *Heterotrypa*. In this restricted sense *Monticulipora* can, of course, include only a small proportion of the large number of Bryozoa that have from time to time been referred to the genus. It is only another instance showing the absolute necessity of clearly describing and illustrating the minute characters, both external and internal, of the typical species of all genera. At least sixteen species are known to me having the essential characters of *M. mammulata*. Of this number only nine have been described, the remainder being new and awaiting opportunities for proper publication.

Position and locality:—So far as known, the genus is first met in Trenton strata, but before the close of the Lower Silurian age, *i. e.*, the deposition of the Cincinnati group, it had already reached the culminating point in its development, since only a single species, the *M. winchelli* from the Hamilton group of Michigan, is known from rocks of later date.

MONTICULIPORA LAMELLOSA Ulrich.

Pl. XXXII, fig. 4-4*b*.

Zoarium large, growing upon some foreign object, composed of one or more layers, each from one to four or five mm. in thickness; the type specimen is a large mass composed of six or seven layers. Surface smooth, showing the surface projections of the acanthopores. Walls of zoœcial tubes thin, of about the same thickness throughout, though a little thickened at the surface. Zoœcia, except just at their origin, direct, about eight in two mm., angular; their apertures also angular. Diaphragms numerous, horizontal, from one-half to their own diameter apart. Cystiphragms few, never arranged in series. Acanthopores moderately numerous, increasing in size toward the surface.

Cystiphragms are rarely detected in sections of this form, yet the general facies of this species and especially the granular nature of the walls, leave little doubt as to its being a member of the genus *Monticulipora*.

Position and locality:—Cincinnati group, Wilmington, Ill.

MONTICULIPORA WINCHELLI Ulrich.

Pl. XLV, fig. 6-6*a*.

Zoarium consisting of a number of superimposed layers, the whole from two to twelve mm. in thickness, the layers from one-half to two mm. thick. Under surface provided with a coarsely wrinkled epitheca. Upper surface showing slightly elevated clusters of larger cells, about 4 mm. apart, measuring from center to center. Walls of zoœcia rather thin. Zoœcia angular, irregularly hexagonal, those of the normal size seven or eight in two mm., those in the clusters from one-third to one-half larger. Apertures angular. Cystiphragms closely set, very large, leaving but a small visceral cavity; occasionally infundibular. Acanthopores apparently wanting.

Owing to the large crescentic shape and closeness of the cystiphragms, vertical sections present appearances which at first sight are very puzzling. The tubes seem to be tabulated very differently. This is due to the shape of the cystiphragms and their not being arranged in the same way in all the tubes. A vertical section of the zoarium cuts a few tubes through the center but most of them at a greater or less distance from it. Only when the section passes through the extremely small visceral cavity, is the usual overlapping appearance of cystiphragms shown, and the narrow visceral cavity seen to be crossed by diaphragms. When the section does not pass through the visceral cavity, and it rarely does, the diaphragms seem curved or horizontal and to extend clear across the tube. The appearance presented by cutting through an infundibular cystiphragm is shown at the top of the third tube from the right, in figure 6*a* of plate XLV.

The general features of the zoarium are decidedly like those of several Lower Silurian species of the genus. The large size of the cystiphragms, the consequent slenderness of the visceral cavity, and the apparent absence of acanthopores, are marked peculiarities of the species.

Position and locality:—Hamilton group, Thunder Bay, Mich.

HOMOTRYPA Ulrich, 1882.

(Jour. Cin. Soc. Nat. Hist., Vol. V, p. 240.)

(For generic diagnosis see page 370.)

Already ten (?) species belonging to this genus have been described, yet this is scarcely one-half of the species known to me. The Cincinnati group furnishes the largest proportion of them, and, like *Monticulipora*, only one species is known to have existed at any subsequent period. The characters of the genus are remarkably persistent and nearly always easily recognized.

HOMOTRYPA ARBUSCULA Ulrich.

Pl. XXXVIII, fig. 3, 3 *c*.

Zoarium loosely attached to foreign bodies by a broad basal expansion, from which grow a number of stout dendroidal stems with freely inosculating branches. Stems diminishing from twelve mm. in diameter at the base to three or four at the free terminations. Surface smooth, with scarcely noticeable clusters of larger cells. Cell apertures oblique, angular and slightly elongated, varying in diameter from the average of 0.18 or 0.20 mm., to 0.3 mm., the diameter of those in the clusters. When well preserved, the cells have their margins beset with very small granules, which may be only surface ornamentations, as no evidences of acanthopores have yet been detected in tangential sections. Walls of zoœcial tubes slightly flexuous and crenulate, very thin in the axial region and but little thickened in the peripheral region. Zoœcial tubes oblique throughout their course, with an unusually gradual curve from their origin to the surface. Apertures seven or eight in two mm. A few mesopores with diaphragms somewhat less than their diameter apart are developed in the cortical region. One, occasionally two, cystiphragms are developed in the zoœcial tubes in the transition period.

In the case of complete specimens, the growth alone will easily separate this species from similar forms. Fragments are readily distinguished by the thin walls, and more than usual obliquity of the cell apertures from any Lower Silurian species known to me. In the brevity of the pheripheral region this species is like *H. dawsoni* Nicholson, but the frondescent growth and pronounced monticules of that species give it an entirely different appearance.

Position and locality:—Birdseye horizon of the Trenton group, High Bridge, Ky.; Calhoun Co., and near Dixon, Ill.

HOMOTRYPA GELASINOSA Ulrich.

Pl. XXXII, fig. 2-2*d*.

Zoarium consisting of flattened branches, four mm., more or less, in thickness. Surface without monticules, but marked with conspicuous, elongated, parallel, dimple-like maculæ, arranged in transverse rows. Walls of zoœcia thin, and flexuous or wavy in the axial region, moderately thickened near the surface. Zoœcia subangular, about ten of the ordinary size in two mm., those forming the borders of the maculæ about one-half larger. Mesopores angular, comparatively large and shallow, present in the dimples only. Diaphragms occasionally present in the axial region. Cystiphragms rather closely set. In the mesopores there are two or three diaphragms in the space of a tube diameter. Acanthopores commonly situated in the angles of the zoœcia, sometimes found in the axial region; now and then they do not follow the trend of the zoœcia in the cortical region, but cut across the tubes at an acute angle. The acanthopores found in the maculæ are longer and larger than the others. In some parts of a longitudinal section, the acanthopores are seen to have exceedingly thin cross partitions.

The elongated dimples distinguish this species from all other described forms of the genus. An undescribed related form, occurring in the Cincinnati group, at Waynesville, Ohio, also has somewhat similar elongated dimples, but differs in other characters.

Position and locality:—Cincinnati group, Wilmington, Ill.

HOMOTRYPA FLABELLARIS Ulrich.

Pl. XXXII, fig. 3-3*c*

Zoarium consisting typically of fan-shaped fronds; an almost perfect specimen gives the following measurements: width 45 mm., height 50 mm., thickness 5 mm. Surface smooth, with obscure maculæ about four mm. apart, measuring from center to center. Peripheral portion of zoarium narrow. Walls of zoœcial tubes flexuous or crenulated in the axial region, and very thin even in the cortical region. Zoœcia apertures angular, slightly oblique, from eight to ten in two mm., those in the maculæ from a third to a half larger than the average. Mesopores few, gathered into clusters in the maculæ. Zoœcial tubes provided with a few remote straight diaphragms in the axial region. Diaphragms moderately numerous in the mesopores. Cystiphragms form a short series in each tube. Acanthopores few, very small.

A very close variety occurs in the upper beds of the Cincinnati group, at Blanchester, Ohio, which has the maculæ a little more pronounced, and a tendency to a ramose growth. The thin walls and flabellate growth distinguish *H. flabellaris* from the hitherto described species of the genus.

Position and locality:—Cincinnati group, Wilmington, Ill.

HOMOTRYPELLA Ulrich, 1886.

(14th Ann. Rep. State Geol. Minn. p. 83.)
(For generic diagnois see page 370).

This genus was established to receive a small but natural group of species that could not be included in any of the other genera of the family. The ramose habit of growth ally the genus to *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: the zoaria of the first are bifoliate, of the latter parasitic; in both the cystiphragms are developed in an almost uninterrupted series to the zoœcial apertures. In the structure of the walls the typical species presents close resemblance to *Peronopora*, while that of *H. contexta*, shows greater likeness to *Atactoporella*. The aggregate of characters thus indicate an intermediate position between *Homotrypa* on the one side, and *Peronopora* and *Atactoporella* on the other.

HOMOTRYPELLA CONTEXTA Ulrich.

Pl. XXXII, fig. 5-5b.

Zoarium consisting of a mass of irregular, coalescing branches varying in thickness from three to six mm. Surface smooth, exhibiting spaces where both zoœcia and mesopores are larger than ordinary. Walls of zoœcia scarcely thickened in the cortical region. Zoœcia sub-circular or oval, from eight to ten in two mm., about 0.15 mm. in diameter, occasionally in contact, ordinarily separated by the angular, thin-walled mesopores, which are very numerous and differ but little in size from the zoœcia. Diaphragms few in the axial region, but becoming more numerous as the zoœcial tubes approach the peripheral region. Here they are abundant, extending from the overlapping cystiphragms to the opposite wall of the tube. In the mesopores the diaphragms are closely set, and approximately upon the same level in all, two or three in the space of a tube diameter. Acanthopores rather small, but a conspicuous feature in tangential sections, situated in the walls of the zoœcia, from three to five surrounding each zoœcium; also at some of the angles between the mesopores.

Position and locality:—Cincinnati group, Wilmington, Ill.

HETEROTRYPA Nicholson, 1879.

(Pal. Tab. Corals p. 291.)

(For generic diagnosis see page 371.)

As defined by Dr. Nicholson this genus included very diverse material, the only characters common to the assemblage being the possession of two sets of cells (*i. e.* zoœcia and mesopores). In the "Am. Pal. Bry." I have shown that only one of the seventeen species which he refers to the genus is congeneric with the type species, *H. frondosa* d'Orb., (*H. mammulata* Nich., non d'Orb). The remaining fifteen species are distributed among the genera *Callopora*, *Homotrypa*, *Amplexopora* (?), *Monotrypella*, *Batostoma* and *Batostomella*. The amended definition of the genus as then proposed by me is now somewhat modified by the elimination of *H. vaupeli*, which I now refer to *Nicholsonella*. The restricted group is closely allied to *Dekayia* Ed. & H., and comprises at least nine species, all of them from the Cincinnati group. Three of these remain undescribed.

HETEROTRYPA PROLIFICA Ulrich.

Pl. XXXVII, fig. 1-1d.

Zoarium frondescent, or subramose with much flattened branches, varying in thickness from four to twelve mm., and at times attaining a height of ten cm. Low rounded tuberosities arranged in irregularly interesecting 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. Zoœcia apertures sub-polygonal, about eight in two 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.

Position and locality: Cincinnati group. A common form in the upper beds at Blanchester, Ohio. It also occurs at Wilmington, Ill. The *H. frondosa* is restricted to the lower half of the Cincinnati group.

HETEROTRYPA INFLECTA Ulrich.

Pl. XXXVII, fig. 2-2*d*.

Zoarium frondescent, seldom over four cm. in width, six cm. in heighth, and five mm. thick; usually only about three in thickness. Surface smooth or with slight elevations of cell apertures somewhat larger than the average. Zoœcial tubes bending abruptly into the cortical region, with walls slightly flexuous in the axial region. Zoœcia apertures circular, 0.14 to 0.18 mm. in diameter, with about eight in two mm. A large but variable number of angular mesopores scattered among the zoœcia, rather more numerous in the clusters. Diaphragms only one or two in each zoœcial tube; numerous in the mesopores. Acanthopores present in considerable numbers, frequently indenting the visceral cavity, in well preserved specimens very conspicuous on the surface, giving it a hirsute appearance.

This species is distinguished externally from *H. frondosa* D'Orbigny, its nearest ally, by its much more delicate growth, strictly frondescent form, monticules wanting or but little elevated, conspicuous acanthopores and larger number of mesopores. Internally it has very few diaphragms, which structures are abundant in *M. frondosa*.

Position and locality:—Cincinnati group, Cincinnati, Ohio.

HETEROTRYPA SINGULARIS Ulrich.

Pl. XXXVII. fig. 3-3*e*.

Zoarium subramose, at times attaining a thickness of seven cm. Surface smooth, or nearly so, with clusters of cell apertures a little larger than the average. Zoœcia about nine in two 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 visceral 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 in 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*.

Position and locality:—Cincinnati group, Wilmington, Ill.

DEKAYIA Edwards and Haime, 1850.

(Pol. Foss. des Terr. Pal. p. 277.)

(For generic diagnosis see p. 371.)

Extensive remarks upon the position of this genus, as well as full descriptions of a number of species, will be found in my "Amer. Pal. Bry."* to which I refer the reader. *D. aspera* Ed. & H., the typical species, occurs in rocks of the Cincinnati group, near Wilmington, Ill. The specimens are in a bad state of preservation, but I had no difficulty in identifying them by means of thin sections. The following species is the only one known from rocks above the Lower Silurian.

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* Jour. Cin. Soc. Nat. Hist. Vol. VI, pp. 84 and 148-155.

Dekayia devonica Ulrich.

Pl. XLV, fig. 5-5*d*.

Zoarium ramose, consisting of small subcylindrical irregular branches, averaging six or seven mm. in thickness; in one instance solid, in all the others hollow with a wrinkled epitheca lining the interior; in the latter the zoarium has a thickness of less than 1 mm. Surface level or with slightly elevated clusters of larger apertures and bristling with very prominent spines 1 mm. or a little less apart. Zoœcia angular, quite oblique to the surface, thin-walled throughout, about five in two mm., measuring longitudinally, with elongated, unequal apertures. Diaphragms few, one, or perhaps more to a tube. Acanthopores exceedingly prominent, with very thick walls.

The examples from New York are hollow and appear to be composed of one or more very thin layers. The specimen from the Ohio Falls has a solid axis. The extreme obliquity of the zoœcial tubes and the very strong acanthopores distinguish this form from any Devonian bryozoan known to me.

Position and locality:—Devonian; Falls of the Ohio; Eighteen Mile Creek, N. Y. (Hamilton group).

Callopora Hall, 1852.

(Pal. N. Y. vol. II, p. 144.)

(For generic diagnosis, see page 372.)

This is a distinct and easily recognized genus, and so far as known, its range does not extend into Devonian deposits, but in all the groups of rocks between the Trenton limestone and the Lower Helderberg, inclusive, it is represented by from one to twelve species. In all, twenty species have been studied, but only thirteen of them are described. The first species to follow Hall's generic description is his *C. elegantula*, from the Niagara group at Lockport, N. Y. According to commonly accepted rules of nomenclature, the species must stand as the type of the genus. Of the remaining species which Hall described and referred to the genus in 1852, *C. aspera* and probably *C. florida* and *C. laminata* belong to *Leioclema* as now understood; while *C. nummiformis* is very likely referable to *Calloporella*. With the exception of *C. perelegans* none of the species more recently referred to *Callopora* by Prof. Hall seem to have the essential characters of the genus.

Thin sections of *Callopora* exhibit a remarkable uniformity of structure, and it is sometimes very difficult to discriminate between those of closely allied forms. This uniformity is more especially apparent in transverse and vertical sections, but as these are highly diagnostic of the genus, they are necessary to confirm the generic reference. Most of the species form large bushy masses, and the Cincinnati group deposits often furnish some very showy cabinet specimens.

CALLOPORA SUBNODOSA Ulrich.

Pl. XXXIII, fig. 5-5*c*.

Zoarium ramose; stems subcylindrical, from six to twelve mm., or even more in diameter. Surface sometimes nearly smooth, usually tubercled. Tubercles rounded, never conical, more or less elevated, composed of apertures rather larger than the average, and numerous mesopores. Zoœcial walls comparatively thin throughout. Zoœcia approaching the surface in a gentle curve, about seven in two mm.; with circular apertures, ranging from 0.18 to 0.27 mm. in diameter; surrounded by a variable number of angular or subcircular mesopores. The zooecial tubes expand very gradually from the point of their origin until they attain their normal size. In the first part of their course, they have several diaphragms about their own diameter apart; after that, diaphragms become rare and may be entirely absent in the rest of the zoœcial tube. The mesopores are tabulated very closely throughout; about three diaphragms in a space equalling their own diameter.

This species differs from the common *C. ramosa* d'Orbigny in the less prominent monticules, which are rounded instead of conical. The tabulation of the tubes in the two species is also very different. Though very distinct from *C. elegantula* Hall, the type of the genus, it is more nearly related to that form than is any other known species of the genus.

Position and locality: Upper beds of the Cincinnati group, Blanchester, O., and numerous other localities. A variety occurs at Wilmington and Savanna, Ill.

CALLOPORELLA Ulrich, 1882.

("Amer. Pal. Bry." Jour. Cin. Soc. Nat. Hist. Vol. V, p. 154.)

(For generic diagnosis, see page 373.)

The thick ring-like walls of the zoœcial tubes distinguish this genus from *Diplotrypa* Nich., species of which *C. harrisi* Ulr., the type, resembles in other respects. The species next described is only provisionally placed in the genus as better preserved material may show that it is not congeneric with *C. harrisi.*

CALLOPORELLA? NODULOSA Ulrich.

Pl. XXXIII, fig. 4–4*a*.

Zoarium parasitic upon foreign bodies, (so far as observed upon the valves of *Strophomena*,) forming patches of greater or less extent; edge of zoarium inclined to turn up. Surface marked with small conical monticules, a little more than two mm. apart, measuring from center to center, more or less subsolid at the apex, due to the closure of the mesopores, and arranged in diagonally intersecting rows. Apertures circular, about nine in two mm., 0.2 mm. or a little less in diameter. Interspaces occupied by mesopores which are most numerous in the monticules.

The internal structure has not been observed owing to the peculiar character of fossilization which has preserved the external features, but entirely obliterated the internal structure. Hence the species is referred only provisionally to *Calloporella*. The general external appearance is that of *Atactoporella ortoni* Nich., but it wants the petaloid apertures of that species.

Position and locality: Cincinnati group, Savanna, Ill.

TREMATOPORA Hall, 1852.

(Pal. N. Y. Vol. II. p. 149.)

(For generic diagnosis, see page 373.)

This genus was re-defined by me in my "Amer. Pal. Bry." taking *T. tuberculosa* Hall, the first species to follow Prof. Hall's generic description, as the type. Much redistribution of species is the unavoidable result, since but a small proportion of the forty-two American species that had been previously referred to the genus are really congeneric with the typical form.

TREMATOPORA DEBILIS Ulrich.

Pl. XXXIV, fig. 3–3e.

Zoarium consisting of slender, cylindrical, branching stems, from 1.5 to 2 mm. in diameter. Surface smooth. Zoœcial tubes long, bending but little to reach the surface. Cell walls very thin in the axial region, slightly thickened in the cortical region. Zoœcia with apertures circular or nearly so, about 0.15 mm. in diameter, and surrounded by a peristome most elevated at the lower end; closer together transversely than longitudinally, there being about five in one direction and only four in the other in 1 mm. Mesopores interspersed irregularly among the cells, of unequal size, and closed at the surface. Acanthopores few and inconspicuous. An occasional diaphragm is present in in the zoœcial tubes, and from one to three in the mesopores. The cortical region, as shown by a transverse section, is very narrow.

From *T.? nitida* Ulr., this species is distinguished by its more robust growth and larger and differently shaped cells. The cortical region is thinner, and the curve of the zoœcial tubes in approaching the surface is greater in this species. From *T. primigenia* Ulr., a Trenton species of Minnesota, it is easily distinguished by the lack of the maculæ so characteristic of that species. It differs too widely from the other described species of the genus to necessitate comparison.

Position and locality:—(?) Cincinnati group, Alexander Co., Illinois.

TREMATOPORA? NITIDA Ulrich.

Pl. XXXIV, fig. 2–2f.

Zoarium consisting of small cylindrical stems, branching variously, 1 mm. or less in diameter. Zoœcial tubes extending obliquely outwards from the center of the stem, scarcely curving to reach the surface. Walls thin in the axial region, thickened but little towards the surface. Zoœcia often in contact, with apertures sometimes oval, usually pyriform, narrowing above, surrounded by a narrow peristome, obsolete or less distinct at the upper end; about six or seven in the space of one mm. measuring longitudinally, and eight to ten measuring transversely, arranged in irregular, obliquely ascending lines. Interstitial spaces irregular, more or less depressed, apparently solid at the surface, but in thin sections seen to be occupied by elongated mesopores. Acanthopores moderately abundant, small, sometimes conspicuous. Diaphragms two or three in the mesopores, rarely present in the zoœcial tubes.

This species is associated with a number of other small forms, from all of which it is readily separated by its very much smaller cells, and characteristic pear-shaped openings. This is probably the smallest species of the genus. Its small size and pyriform apertures at once distinguish it from its nearest congeners *T. debilis* and *T. primigenia* Ulr.

Since the above was written a large series of specimens of this species have been collected. These show that the base of the branches was pointed and that the zoarium was jointed at irregular intervals. It is, therefore, probable that the species belongs to another genus.

Position and locality:—Cincinnati group, at Savannah, Ill., where it is very abundant at an horizon about 150 feet above the river.

TREMATOPORA CALLOPOROIDES Ulrich.

Pl. XXXIV, fig. 1—1d.

Zoarium irregularly ramose, branches from four to seven mm. in diameter. Surface marked by faint monticules whose centers, occupied by sub-stellate groups of mesopores with closed apertures, present an apparently solid aspect. Distance between centers of monticules two or three mm. Zoœcial tubes run irregularly in the axial region, curve gradually, and at the surface are almost direct. Walls thin in the axial region and but little thickened in the cortical region. Zoœcia seven or eight in the space of two mm., with sub-angular or sub-circular apertures. Peristome faint. Interspaces occupied by very thin-walled, angular mesopores, which are sometimes open at the surface. When this is the case, the surface resembles that of some species of *Callopora*. From four to seven diaphragms are developed in the zoœcial tubes as they leave the axial region. Diaphragms numerous in the mesopores. Acanthopores small and usually inconspicuous, often projecting a little into the zoœcial cavity owing to the thinness of the walls.

The characters of this species are so distinct from *T. debilis* with which it is associated, and from other species of the genus that comparisons are unnecessary. Its surface bears some resemblance to certain species of *Callopora*, but the internal structure is widely different.

Position and locality: Cincinnati group, Alexander County, Illinois.

NICHOLSONELLA Ulrich.

(For generic diagnosis see page 374.)

Only four or five species are known having the peculiar characters upon which this genus is founded. Two of these, *N. ponderosa*, the type of the genus, and an undescribed species, are from the Trenton limestone, the other two or three from the Cincinnati group. Of the latter, *N. vaupeli* was described by me as a species of *Heterotrypa*.* It is not uncommon near the tops of the hills at Cincinnati, Ohio. A closely allied species or variety occurs about 250 feet higher in the series and is bundant at several localities in Ohio. The fourth form is described here for the first time. It also belongs to the Cincinnati group, but is not yet known from any other locality than Wilmington, Ill.

The affinities of *Nicholsonella*, are with *Constellaria* Dana, but the absence of stellate maculæ, is quite sufficient to distinguish them. The frondescent species resemble *Heterotrypa* Nich., but the relationship is much more remote than I at one time thought.

The generic name is given in honor of Dr. H. Alleyne Nicholson, as a slight token of my appreciation of the great value of

*Jour. Cin. Soc. Nat. Hist., vol. VI, p. 85.

his labors, in micropalæontology. To him belongs the credit of being the first to make extensive use of the microscope in classifying the "Monticuliporidæ."

NICHOLSONELLA PONDEROSA Ulrich.

Pl. XXXIV, Figs. 5–5d.

Zoarium large, consisting of very irregular, inosculating, flattened branches or fronds, from one to two and one-half cm. in thickness. The largest example is twelve cm. in height. Surface even, exhibiting rather inconspicuous maculæ in which the zoœcia are slightly larger and separated by wider interspaces than usual. Zoœcia curving rapidly from the axial region to the surface, where they open with regularly arranged circular apertures, about 0.21 mm. in diameter; eight in three mm. Peristome very faint, carrying from eight to twelve small granules. Interspaces either appearing solid and minutely granulose, or showing the angular mouths of a single row of rather large mesopores; in the maculæ there are two rows. In the spaces between the maculæ, the zoœcia apertures are separated by interspaces varying in width from 0.1 to 0.2 mm. Mesopores are developed in moderate numbers already in the axial region. Diaphragms not very numerous, being most so in the peripheral region, where they are distant from each other from one to nearly three tube-diameters. In the mesopores they are thick, and about their own diameter apart.

The large flattened branches and irregular growth distinguish this species from all Bryozoa known to me from this horizon. It is much larger than *N. vaupeli* Ulr., from the Cincinnati group, while *N. cumulata* differs decidedly in structure and zoarial habit.

Position and locality: Trenton group, Dixon, Ill.

I am indebted to Dr. Everett for two good examples. Some smaller subramose specimens from near Beloit, Wis., may belong to this species but their preservation is such that I could not satisfy myself of their identity.

Nicholsonella cumulata Ulrich.

Pl. XXXIII, Fig. 6-6c.

Zoarium very irregular, sometimes submassive, at other times subramose, consisting of one or more superimposed layers, from 0.7 to 4 mm. in thickness, with the inner side generally covered by an epithecal membrane or loosely attached to other bodies. In one (a lobate mass having a tendency to become massive) the central regions are solid in the sense that the tubes traverse an "axial region." Surface sometimes smooth, but generally with low, rounded, rather regularly arranged monticules, two mm. or a little more apart, measuring from center to center. On these monticules the zoœcia are scarcely larger than those in the intermediate spaces, but they are separated by wider interspaces. Zoœcial tubes slightly curved near the origin in each layer, after which they proceed direct to the surface. In this portion they are crossed by diaphragms from once to twice their diameter apart. Apertures subcircular, the average diameter 0.18 mm.; when perfect with a faintly elevated and minutely spinulose margin; about seven in two mm.; arrangement moderately regular. Interspaces varying in width, usually narrow, usually almost half as wide as the zoœcia, occupied by small, closely tabulated, angular mesopores, which, just beneath the aperture surface of each layer, are filled with a dense deposit. The minute mural tubuli, best shown in this deposit, are a less marked feature than in the more typical species.

The habit of growth distinguish the species from both *N. ponderosa* and *N. vaupeli*. The absence of stellate maculæ distinguish specimens from an associated species of *Constellaria*, that is closely allied to *C. limitaris* Ulr.

Position and locality: Cincinnati group, Wilmington, Illinois; very abundant.

Constellaria Dana, 1848.

(Zoophytes, p. 537.)

(For generic diagnosis see page 374.)

The type of this genus is my *C. florida*.* For many years it was regarded as identical with *Stellipora antheloidea* Hall, and

*Jour. Cin. Soc. Nat. Hist., Vol. V, p. 257, and Vol. VI, p. 267.

the New York types of that species seemed to have been lost sight of entirely. Several years ago having had an opportunity of examining Hall's original specimens, together with another set of authentic examples, I came to the conclusion that the Cincinnati specimens belonged not only to another species, but to a distinct genus as well. In 1848 Dana proposed the genus *Constellaria* for the Cincinnati species, but failed to give it a specific name, and, as I have said till recently, it has gone current as either *Constellaria* or *Stellipora antheloidea*. In 1875, Nicholson described and figured a closely allied but distinct species under the name *Constellaria polystomella*†. Examples of this species are not uncommon at several localities in Ohio and Indiana, where the upper layers of the Cincinnati group are exposed. The species also occurs at an equivalent horizon in Wisconsin and Illinois, but has not been found at Cincinnati. As it differs both internally and externally from the Cincinnati species, I could not accept Mr. Whitfield's proposition to apply Nicholson's name to all the western‡ forms, but considered myself justified in applying the new name *florida* to the common Cincinnati species.

The genus as defined by me includes at least five species and several varieties, all of them from the Cincinnati rocks. What may prove another species, closely allied to *C. limitaris*, occurs at Wilmington, Ill.

CONSTELLARIA PARVA Ulrich.

Pl. XXXIV, Figs. 1-1b.

Zoarium consisting of irregularly undulating small fronds, two to three mm. in thickness, and twenty-five mm. or more in height, growing from a broad basal expansion. Surface smooth, showing small star-shaped maculæ of the type characteristic of the genus, varying from one to one and one-half mm. apart, measuring from center to center, and averaging sixty in the space of ten mm. square. Zoœcial walls comparatively thin throughout, though ring-like in the mature region. Zoœcial

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†Pal. Ohio, Vol. II. p. 215.

‡Geol. of Wis., Vol. IV, p. 251, 1882.

tubes bending rather abruptly from the axial to the peripheral region, about 0.08 mm. in diameter in the spaces between the stars, while the two to six zoœcia between the rays of the maculæ are slightly larger, sometimes having a diameter of 0.13 mm.; apertures circular, with peristome. The angular, thin-walled mesopores are arranged in star-shaped maculæ, and in the intermediate spaces surround the zoœcia in one or two series; they vary in size being generally smaller than the zoœcia, and largest at the center of a macula. Diaphragms from one-half to one tube diameter apart in the peripheral region of the zoœcial tubes, and from one to two tube-diameters apart in the axial region; very crowded and apparently upon the same level in contiguous mesopores.

This species resembles *C. fischeri* Ulr., but forms smaller and thinner fronds, and has diaphragms throughout the zoœcial tubes; the disproportion in the size of the two sets of tubes is much less, the zoœcia are smaller, and a greater number of mesopores is found surrounding the zoœcia in this species.

Position and locality: Cincinnati group, Wilmington, Ill.

Leioclema Ulrich, 1882.

("Am. Pal. Bry." Jour. Cin. Soc. Nat. Hist. Vol. V, p. 141.)

(For generic diagnosis see page 376.)

When this genus was proposed I was acquainted with the type species, *Callopora punctata* Hall, only. Now, by extending the limits, fifteen species are united under the name. Five are here described as new, the remainder, with one exception, having been previously described by Prof. Hall as species of *Callopora.* It is possible that more than one generic group is included in the genus as now defined, but, as I found no characters upon which to base satisfactory divisions, I have thought it advisable to arrange them provisionally as one generic group. The species are distributed as follows: *L.? wilmingtonense* Ulr., in the Cincinnati group; *L. singulare, asperum, floridum,* and (?) *laminatum* of Hall in the Niagara group; *L. cellulosum, parasiticum,* and *ponderosum* of Hall, in the Lower Helderberg group; *L. occidens* (*Fistulipora occidens* Hall and Whitfield) in the Hamilton group; *L. wachsmuthi* and *subglobosum* Ulr., in the

Kinderhook group; *L. gracillimum* Ulr., in the Burlington and Keokuk groups; *L. punctatum* Hall, and *L. foliatum* Ulr., in the Keokuk group, and *L.? araneum* Ulr., in the Chester group. Beside, several undescribed species are known, one from the Hamilton, one from the Keokuk, one from the Chester, and another from the Coal Measures.

LEIOCLEMA WILMINGTONENSE Ulrich.

Pl. XXXIV, fig. 4-4*b*.

Zoarium compressed, subramose; the type specimen is about twenty-two mm. in width and about ten mm. in thickness. surface smooth, unmarked by maculæ,or monticules. Zoœcial tubes slightly inclined from the vertical in the center of the branch, and reach the surface by a rather sharp curve; provided with a few diaphragms near the cortical region. Walls but little thickened in the peripheral portion. Zoœcia about four to one mm. Apertures of zoœcia circular, about 0.2 mm. in diameter, seldom in contact, being nearly always completely surrounded by angular mesopores, which are almost as large as the zoœcia. Diaphragms numerous in the mesopores, from 0.05 to 0.10 mm. distant from one another. Acanthopores small and inconspicuous.

Some care is required to distinguish this species from the somewhat similar *Homotrypella contexta*, which is associated with it and, like it, has thin-walled zoœcia separated by large mesopores. Sections at once prove the distinctness of the two forms, the species here under consideration being entirely devoid of the cystiphragms which are so abundant in *H. contexta*. The nearest congener of this species is the *L. occidens* Hall and Whitfield.

Position and locality: Cincinnati group, Wilmington, Ill.

LEIOCLEMA OCCIDENS Hall and Whitfield.

Fistulipora occidens H. & W. 23 Reg. Rep. State Mus. N. Y., p. 228. Pl. V, fig. 9, 10; 1875.

Callopora cincinnatiensis Ulrich. Jour. Cin. Soc. Nat. Hist. Vol. I, p. 93, Pl. IV, fig. 8-8*b*, 1878; Ibid. Vol. V, p. 142; Pl. VI, fig. 18-18*a*, 1882.

Zoarium exceedingly variable in form, commonly irregularly ramose or lobate. Surface smooth, occasionally (in exceptionally well preserved specimens) minutely spinulose; but this is never a conspicuous feature. Walls of zoœcia thin, somewhat flexuous in the axial region, slightly thickened in the peripheral region. Apertures of zoœcia circular from 0.15 to 0.20 mm. in diameter, seven or eight in the space of two mm.; encircled by a single series of large angular or subcircular mesopores, on an average about two-thirds the size of the true zoœcia. Diaphragms rather few and remote in the zoœcial tubes, in the mesopores more numerous, and about their diameter or more apart. Acanthopores small, present in moderate numbers, and at times encroaching a little upon the zoœcia.

Aside from *L. minutum* (?) Rominger, the nearest congener of this species is *L.? wilmingtonense* from Silurian strata. These species have a facies rather different from the other species of this genus, and should perhaps form a separate genus. In that case *L. subglobosum*, and possibly *L. wachsmuthi* as well, will go with them.

Small examples of this species have been described by the author as *Callopora cincinnatiensis*. The specimens were furnished him by Mr. Fred Braun, who stated that he had collected them from strata of the Cincinnati group, at Cincinnati, O. This is now known to be an error, and careful comparison with Iowa examples leaves no doubt as to their having been collected at some western locality.

Position and locality: Hamilton group. Occurs abundantly at several localities in Iowa; (Independence, Rockford and Buffalo); also at Rock Island, Ill.

LEIOCLEMA MINUTUM Rominger?.

?*Fistulipora minuta*, Rominger, 1866. Proc. Acad. Nat. Sci. Phila. p. 120.

Callopora minutissima Nicholson, 1875. Rep't. Pal. Ontario, p. 77, fig. 43.

This common species of the Hamilton group, closely resembles the preceding in its minute structure, and it would be difficult to point out any differences between them, excepting that of zoarial habit. *L. minuta*, so far as observed, invariably occurs as thin incrusting layers, a mm. or less in thickness, that by superimposition of successive layers may eventually form small masses. Such specimens are more common in the western localities than in Michigan and Canada.

The species is identified with authentic examples of the species, agreeing in most respects with Rominger's brief description. The interspaces are, however, not vesiculose, but occupied by unmistakable mesopores, with open apertures. The structure, therefore, is not as in *Fistulipora.* Should an examination of Rominger's original types prove his species distinct, then Nicholson's name will stand.

Position and locality: Common at Buffalo and Davenport in Iowa, Andalusia and Rock Island, in Ill., and at several localities in Northern Michigan and Western Ontario.

Leioclema wachsmuthi Ulrich.

Pl. LXXV, fig. 7, 7b..

Zoarium a thin expansion, consisting of one or more superimposed layers, each one mm. or less in thickness; the lower surface provided with a finely wrinkled epithecal membrane. Surface irregularly undulating or montiferous, occasionally showing a tendency to throw up short, slender branches, from one to two mm. in diameter. Zoœcia about six in the space of two mm. with thin walls, at first prostrate, then curving and opening perpendicularly to the surface. Apertures mostly oval, some circular, their longer diameter about 0.2 mm.; their margins beset with small spinules, the surface projections of the acanthopores which occasionally project into the visceral cavity and give the aperture a floriform aspect. Mesopores angular, very numerous, completely encircling the zoœcia in from one to three rows.

The thin laminar growth, and the exceeding abundance of the mesopores are the most marked features of this species.

Position and locality: Kinderhook group, Marshalltown, Ia.

Leioclema subglobosum Ulrich.

Pl. LXXV, fig. 8, 8b.

Zoarium subglobose, pedunculate, base sometimes expanded. Surface smooth. Zoœcia radiating out in curved lines in all directions from the center of the base. Tube walls thicken inappreciably as they near the surface. Zoœcia eight or nine in the space of two mm., with circular or oval apertures 0.15 to 0.2 mm. in diameter. Zoœcia separated by angular or subcircular mesopores arranged in a single or double series, sometimes forming small clusters. Mesopores from one-half to three-fourths as large as the zoœcia. Diaphragms fairly abundant throughout the zoœcial tubes, very numerous and closely set in the mesopores. Sections present obscure evidences of the diaphragms of the mesopores having a central perforation. Acanthopores numerous and of large size.

The figure of the tangential section (Pl. LXXV. fig. 8b) does not represent the structure as well as it might. Some of the acanthopores are made too prominent and others overlooked entirely. This is due to the peculiar fossilization by which the internal characters are much obscured. The globose form in connection with the strong tabulation easily distinguish this species from the other species of the genus.

Position and locality: Kinderhood group, Marshalltown, Ia.

Leioclema gracillimum Ulrich.

Pl. LXXV, fig. 6, 6b.

Zoarium ramose, branching regularly; branches from one to one and a half mm. in diameter. Surface even. Apertures of zoœcia elliptical, about 0.15 mm. in their longer diameter, and 0.1 mm. in their shorter diameter, eight or nine in two mm.; surrounded by a large number of very small mesopores. Acanthopores small, numerous.

This species is closely allied to *L. punctatum*, but is distinguished from it by its smaller cells, and smaller branches, which are also more constant in size. It seems to have an extended vertical range. The typical form is from the Keokuk group. Specimens which cannot be distinguished from the typical forms are found in the Kinderhook, Burlington and Warsaw groups.

Position and locality: Occurs at most localities of the Keokuk group; in the Kinderhook group at Marshalltown, Ia; in the Burlington group at Burlington, Iowa, and in the Warsaw beds, at Warsaw, Ill.

LEIOCLEMA PUNCTATUM Hall.

Callopora punctata Hall, 1858. Geol. Iowa, Vol. I, part II. Pal. p. 653.

Callopora missouriensis Rominger, 1866. Proc. Acad. Nat. Sci. Phila. p. 117.

Leioclema punctata Ulrich, 1882. Jour. Cin. Soc. Nat. Hist. Vol. V. p. 141.

Pl. VI, fig. 1, 1a.

Zoarium ramose, reaching a height sometimes of fifteen to twenty cm., branches from two to five, generally about four mm. in diameter, springing from a broad irregular basal expansion, which may be free and with a wrinkled basal epitheca or attached to foreign bodies. Surface smooth or slightly tubercled, in well preserved specimens, spinulose, having a hirsute appearance under a pocket lens. Walls of zoœcia flexuous in the axial region, comparatively thick in the peripheral region. Zoœcia about five or six in the space of two mm., with sub-circular, or petaloid apertures, from 0.15 to 0.2 mm. in diameter. Mesopores sub-angular, small, their diameter about one-third that of the zoœcia, arranged in two or three or more series about the zoœcia, frequently aggregated into large irregular groups, comparatively more numerous on the basal portion than higher up on the zoarium. Diaphragms strong, few and remote in the zoœcial tubes, more numerous and about their own diameter apart in the mesopores. Acanthopores large and numerous, from four to seven encircling the zoœcia and encroaching upon their visceral cavity, causing the floriform appearance of the zoœcia observed in tangential sections and upon the surface.

The robust habit of growth distinguishes this species from *L. gracillimum*. The great abundance of mesopores and acanthopores, in connection with the growth, separates it from all other species of the genus.

Position and locality: This is the most abundant species in the Keokuk limestone, occurring at Keokuk and other localities in Iowa; Warsaw Ill.; Lagrange, Mo. (Rominger); and King's Mountain, Ky. Also in the Warsaw beds.

LEIOCLEMA FOLIATUM Ulrich.

(Fig. 1, page 301.)

Zoarium a delicate laminar expansion, from one-half to one and a half mm. in thickness, with a thin wrinkled epitheca on the under surface. Upper surface even, spinulose, with a hirsute appearance. Zoœcia, except at their origin, direct, with thin walls, about six in the space of two mm. Apertures circular, petaloid, about 0.2 mm. in diameter. Mesopores small, angular or subcircular, arranged in a single, occasionally a double row about the zoœcia. Diaphragms thin, few and remote in the zoœcial tubes, rather more than their own diameter apart in the mesopores, sometimes apparently wanting even in these. Acanthopores very large and prominent, usually three, sometimes four, surrounding each zoœcium and projecting more or less into its cavity.

The laminar form, less numerous acanthopores, and comparatively small number of mesopores, distinguish this species from the *L. punctatum*, occurring in the same beds.

Position and locality: Warsaw beds, Warsaw, Ill.

LEIOCLEMA? ARANEUM Ulrich.

Pl. LXXV, Fig. 9-9c.

Zoarium consisting of a thin crust, about one-half mm. in thickness, attached to foreign bodies, sometimes throwing up small, short branches. Surface generally even, sometimes marked with small, pointed tubercles. Zoœcia arranged radially about one or more centers; at first prostrate, soon proceeding directly to the surface, nine or ten in the space of two mm., sometimes in contact, at other times separated by mesopores. Apertures oval, their longer diameter scarcely 0.2 mm. Mesopores small, irregular in shape, frequently compressed between the zoœcia, scattered about rather promiscuously, commonly aggregated into clusters, which are often elevated into conical monticules, appearing subsolid at the surface. Diaphragms closely set in the zoœcial tubes, about three in the space of a tube diameter, a little more closely set in the mesopores. Acanthopores very small, situated in the wall of the zoœcium, with from seven to ten encircling each zoœcium.

Different examples show considerable variation in the number of mesopores. The most marked features of this species are the tenuity of the zoarium, the small size of the zoœcia, the comparatively small number of mesopores, the large number and extreme minuteness of the acanthopores, and the nearly equal tabulation of zoœcial tubes and mesopores. It prefers to attach itself to the shells of Brachiopoda, though it is found adherent to other organisms as well.

Position and locality: Monroe Co., Ill.; Chester, Ill.; Pulaski and Jackson Co., Ky.; and probably at all typical localities of the Chester group.

BATOSTOMELLA Ulrich, 1882.

(Jour. Cin. Soc. Nat. Hist. Vol. V, p. 141 and 154).

(For generic diagnosis see page 375.)

This genus attained its maximum and most typical development during Carboniferous time. With perhaps three or four exceptions, the Silurian and Devonian species present peculiarities which, when once we have a good understanding of this group of fossils, may necessitate their removal to other genera. The two species next described belong to these doubtful forms, but the four following them are typical members of the genus. A small portion of a tangential section taken from an unusually well preserved example of *B. gracilis* is figured on plate XXXV, fig. 2. It should be compared with the sections of *B. obliqua* figured on plate XLVI.

BATOSTOMELLA SIMULATRIX Ulrich.

Pl. XXXV, fig. 1-1*g*.

Zoarium dendroidal, throwing off cylindrical branches from two to five mm. in diameter. Surface smooth, with clusters not at all or but slightly elevated, in which the interspaces between the cells are wider and mesopores more abundant than elsewhere. Zoœcial tubes a little irregular in their course in the axial portion, quite oblique in the peripheral zone where their walls become considerably thickened. Apertures of zoœcia oval, owing to the obliquity of the tubes, about 0.2 mm. in their longer diameter and about eight in two mm. measuring longitudinally.

Zoœcial tubes for a short distance after their origin rather closely tabulated, afterwards the diaphragms become about two tube diameters or less apart. Mesopores moderately abundant, with rather close-set diaphragms. Acanthopores very small.

In the oval form of the cells, the numerous mesopores, the frequent closure of the cell apertures by perforated opercular structures, this species is remarkably like *Callopora sigillaroides* Nich., but its internal structure is altogether different. Internally it can scarcely be distinguished from *B. trentonensis* Nich., from the Trenton limestone of Ontario, but the smaller size of this species, and its rather more oval apertures and different horizon discriminate the form from that.

Position and locality: Cincinnati group, Savanna, Ill., and at a number of localities in Ohio and Indiana, where the upper beds of this formation are exposed.

Batostomella obliqua Ulrich.

Pl. XLVI, fig. 2-2*c*.

Zoarium dendroidal, consisting of dichotomously and otherwise branching stems, of an average thickness of six mm. Surface marked with low rounded tubercles composed of larger sized cell apertures; centers of clusters 2.5 mm. apart. Zoœcial tubes slightly tortuous, opening very obliquely upon the surface, their walls thin and somewhat flexuous in the axial region, rather thick in the cortical zone. Both tangential and vertical sections show that the central portion of the wall is granular. Apertures angular, elongated, owing to their obliquity, those occupying the monticules especially so, about seven in two mm. measuring lengthwise. Mesopores few or wanting. Two or three diaphragms developed just before the tubes enter the peripheral region. A few faint and small acanthopores appear to be present in tangential sections; not observed on the surface.

The great obliquity of the tubes, the absence, more or less complete, of mesopores, and the angular elongated apertures are the most distinctive characters of this form. The granular structure of the central portion of the walls is the chief ground for placing this species under *Batostomella*. This peculiar structure is present in well preserved examples of *B. gracilis* James, as figured on plate XXXV, fig. 2.

Position and locality: Hamilton group, Alpena, Michigan. The specimens from which this description is drawn were kindly donated to the author by the Rev. W. H. Barris, of Davenport, Iowa.

BATOSTOMELLA INTERSTINCTA Ulrich.

Pl. LXXV, fig. 4-4c.

Zoarium forming a very thin incrustation, spread upon crinoid columns, throwing up irregularly branched shoots, one mm. or thereabouts in diameter at the basal portion, and somewhat more higher up. Surface smooth; when well preserved hirsute. Zoœcial tubes make a very abrupt bend from the axial to the peripheral region. Apertures varying from circular to oval, about nine in two mm., measuring along the irregular obliquely ascending intersecting rows of apertures. In the thin basal expansion the interspaces are less wide, and there are fewer mesopores. Here the average long diameter of the oval apertures is about 0.18 mm., while upon the ramose portion the diameter of the mostly circular apertures rarely exceeds 0.1 mm. A considerable number of mesopores are developed upon the ramose portion. Diaphragms few or wanting. The cortical region is equal in thickness to about the diameter of the axial region, the most marked peculiarity of this species and one which at once distinguishes it from all other species of the genus.

The irregular growth, large basal expansion, and its larger cell apertures, readily distinguish this species from *B. spinulosa*.

Position and locality: St. Louis group; rather rare at Pella, Iowa.

BATOSTOMELLA SPINULOSA Ulrich.

Pl. LXXV, fig. 1—1e.

Zoarium slender, ramose, branching at greater or less intervals, the cylindrical stems from one to two mm. in diameter. Surface smooth; when well preserved, hirsute. Zoœcial tubes thick-walled and direct in the cortical region after making a rather abrupt turn from the axial region where they are thin-walled. Zoœcial apertures separated by thick interspaces, oval, variable in size, the average long diameter being 0.1 mm., six or seven in two mm., measuring lengthwise. Mesopores small, moderately abundant, circular or broadly oval. Diaphragms often wanting in the zoœcial tubes, never numerous; generally lacking in the mesopores. Acanthopores very numerous, arranged in a circular band about each zoœcium.

The peculiarities of tabulation, the thick walls, and vast number of acanthopores, causing the spinulose aspect of the surface, are the most noticeable features of this species.

Position and locality: Chester group. Abundant at Sloan's Valley, Pulaski Co., and other localities in Kentucky; worn specimens from Chester, Ill., are referred doubtfully to this species.

Batostomella abrupta Ulrich.

Pl. LXXV, fig. 2-2*e*.

Zoarium dendroidal, from two to three mm. in diameter. Surface smooth, hirsute, with clusters of somewhat larger cells. Zoœcial tubes inclining gently outwards from their origin, rather oblique even in the cortical region, causing the apertures to have a somewhat oval shape. Apertures about eight in two mm. When in a good state of preservation the apertures are surrounded by a sloping space. The thick interspaces are occupied by one or two rows of closely arranged small acanthopores. When in two series, they are separated by a groove in which an occasional mesopore of small size may be detected. Walls of zoœcial tubes abruptly thickened in the unusually narrow cortical region. An occasional diaphragm developed in the zoœcial tubes.

The somewhat more robust growth, very narrow cortical region, the larger cells, and the abruptly thickened walls, are the principal points which distinguish this species from *B. spinulosa*, found in the same beds.

Position and locality: Chester group, Sloans Valley, Pulaski Co., Ky. Probably occurs at Chester and other localities in Illinois.

Batostomella nitidula Ulrich.

Pl. LXXV, fig. 3-3*b*.

In this species the zoarium consists of very slender branching stems, about one mm. in thickness. Surface even, hirsute. Cell apertures oval, variable in size, the largest about 0.15 mm. in their longer diameter; about eight in two mm., with only moderately thick interspaces. Often the cell aperture is provided with an opercular structure having a central perforation. Zoœcial walls frequently flexuous in the axial region, considerably and abruptly thickened in the cortical zone. Mesopores moderately abundant. Diaphragms almost wanting. A single row of acanthopores encircles each zoœcium.

This species holds an intermediate position between *B. spinulosa* and *B. abrupta*. The greater irregularity in branching, the larger cell apertures, less numerous acanthopores, greater obliquity of zoœcial tubes in the axial region, thinner interspaces and other points separate it from *B. spinulosa*. The comparatively wider cortical region, thinner interspaces, fewer acanthopores, and more slender habit of growth, distinguish it from *B. abrupta*.

Position and locality: Chester group; Chester, Ill., and Sloan's Valley, Ky.

Stenopora Lonsdale, 1845.

(Strzelecki's Phys. Desc. N. S. Wales, p. 99.)

(For generic diagnosis see page 375.)

Like the genera *Chaetetes* and *Monticulipora* this genus has for many years served as the receptacle for very diversely constructed Palæozoic Bryozoa. We owe it to the labors of Dr. H. A. Nicholson and Mr. R. Ethridge, Jr., that we now possess some adequate idea of the true structure of the genus, these naturalists having published a short time ago critical descriptions and figures of Lonsdale's types* together with several new species.

The present addition to our knowledge of *Stenopora* makes it abundantly evident that the genus has no affinities with the Favositidæ, but that in *Batostomella* on the one hand, and

* Ann. and Mag. Nat. Hist. Vol. IV, 1879, and Vol. XVII, 1886.

Anisotrypa on the other, we see the closest possible relations. Going a little farther we arrive by easy gradations into most close proximity to such undoubted Bryozoa as *Rhombopora*. Indeed in practice it is not an easy task by any means to draw the line between these genera, though the typical forms appear to differ widely. It will require nothing less than a monographical study to determine the exact limits of each division.

STENOPORA AMERICANA Ulrich.

Pl. LXXIV, fig. 1-1*a*.

Zoarium ramose, branches large, subcylindrical, irregularly divided, twenty-five to forty mm. in diameter, and twelve cm. or more in height. Usually they are very much flattened by pressure, and appear to be frondescent. Surface sometimes smooth, generally marked by somewhat elevated, broad tubercles, whose summits are about four mm. apart. Zoœcia with rounded or polygonal apertures varying according as the interspaces are thick or thin; those on the monticules a half larger than the others; nine or ten of the ordinary size in three mm. Zoœcial tubes thin-walled and vertical in the axial region, then bending rapidly outward proceed direct to the surface; as they enter the peripheral region their walls gradually exhibit the moniliform thickenings characteristic of the genus. These soon become more pronounced and the intervals shorter. Near the surface five to eight occur in two mm. Diaphragms horizontal, perforated. Mesopores absent or very few. Acanthopores of moderate size, fairly abundant, giving to the well preserved surface a spinose aspect.

Position and locality: Keokuk group; Warsaw, and Jersey Co., Ill. Not uncommon.

var. VARSOVIENSIS Ulrich.

Pl. LXXIV, fig. 3, 3a.

This variety has smaller zoœcia and much thicker walls than the typical form. The moniliform thickenings of the walls are also less distinct from each other. The specimens are from Warsaw, Ill.

STENOPORA MONTIFERA Ulrich.

Pl. LXXIV, fig. 4-4*b*.

Zoarium consisting of thin laminæ, which sometimes appear to have been part of large hollow branches. Surface with large and very prominent monticules. Zoœcia eight to ten in three mm.; generally with very thin walls and angular apertures. Remaining external features like those of *S. americana*, of which it may be only a good variety.

The internal structure of these specimens differs slightly from that of typical *S. americana*, the periodic thickening of the walls being more irregular, and the divisional line between the zoœcia marked by a closely arranged series of minute dark spots, which are also to be detected in vertical sections.

Position and locality: Keokuk group, Otter creek, Jersey Co., Ill.; Bentonsport, Iowa, and other localities.

STENOPORA EMACIATA Ulrich.

Pl. LXXIV, Fig. 2-2a.

Zoarium laminar, attaining a considerable width; thickness one mm. or more; under surface provided with a thin wrinkled epitheca. Surface marked with groups of larger cells, which are elevated into low broad monticules, about four mm. apart, measuring from center to center. Apertures polygonal, varying in width from 0.3 mm, in the intermacular spaces, to 0.5 in the clusters, about eight or nine in three mm. Walls very thin, spinose at the angles. Zoœcial tubes bending toward the surface very soon after their origin. Walls very thin throughout, but appreciably thickened at intervals, about seven times in two mm. Mesopores wanting. Perforated diaphragms very thin, a tube diameter or so apart. Acanthopores small, excepting in the clusters of large cells, commonly at the angles, protruding more or less into the zoœcial chambers.

The very thin walls and more numerous diaphragms distinguish this species from *S. montifera*. *S. tuberculata* Prout, differs somewhat in growth, and has the walls more decidedly thickened and at shorter intervals. The diaphragms are also more numerous.

Position and locality: Keokuk group; Warsaw, Ill., and Keokuk, Iowa.

STENOPORA INTERCALARIS Ulrich.

Pl. LXXIV, Fig. 5-5a.

Zoarium consisting of large cylindrical branches from one to two cm. in diameter. Surface smooth, without groups of larger cells. Zoœcia polygonal, somewhat variable in size, apertures subangular, 0.18 to 0.25 mm. in diameter, about ten in three mm. Interspaces moderately thick, with spines at the angles when the surface is well preserved. Walls of zoœcia thin and faintly flexuous in the axial region, thickened and irregularly moniliform in the cortical region, the beads not separated by thin intervals, but merged into each other. Mesopores quite numerous for the genus, small, but varying in size, circular or angular, intermittent and irregular. A few diaphragms developed in the outer part of the axial region, generally absent in the cortical region. Acanthopores numerous, invariably situated at the angles of junction.

This species differs from *S. americana*, with which it is associated, in having no monticules nor clusters of large cells, smaller cell apertures, far greater number of mesopores (which may be detected on the surface) and much fewer diaphragms.

Position and locality: Keokuk group, Warsaw, Ill.

STENOPORA ANGULARIS Ulrich.

Pl. LXXIV, Fig. 6-6b.

Zoarium consisting of extremely massive branches, the largest specimen under investigation being eight cm. wide and four cm. thick just before a bifurcation, the latter measurement being about equivalent to the normal diameter of the branches. Surface smooth but with group of cells decidedly larger than the average. Apertures angular, variable in form, with thin interspaces, about ten in three mm. Walls of tubes thin in the axial region, and but very little thickened in the cortical though preserving the moniliform character of the genus. In the cortical region the zoœcia do not form continuous tubes, but the whole is divisible into a number of distinct thin layers. Mesopores very few. Diaphragms wanting. Acanthopores abundant and commonly occupying the angles, not very large, but conspicuous on account of the tenuity of the walls.

Its large size, comparatively small angular cells, absence of diaphragms, and very thin walls, are characters which, combined, easily distinguish the species from others of the genus.

Position and locality: Keokuk group, Lagrange, Mo.

STENOPORA INTERMITTENS Ulrich.

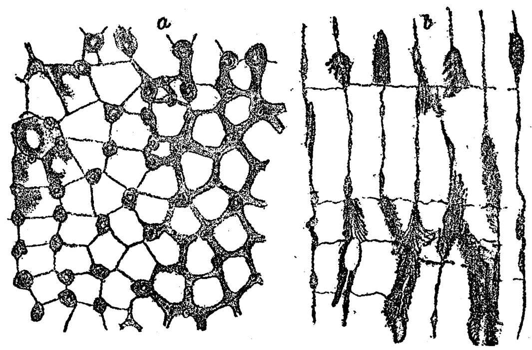

Fig. 16. Sections of *Stenopora intermittens* Ulr., x 18.

a.—tangential section showing extremes in the thickness of the walls, a few perforated diaphragms, and the conspicuous acanthopores; *b.*—vertical section showing the faintly beaded struc ure of the walls, and the intermittent development of the acanthopores.

Zoarium an irregular broad expansion, presenting a very rough aspect. Lower side with a strong epitheca. Upper surface very irregular in its general contour, but exhibiting faintly elevated broad monticules, occupied by cells scarcely larger than the average. Apertures angular, quite regularly polygonal, often quadrate, between seven and eight in two mm. The zoarium seems to be composed of a number of superimposed layers. The zoœcial walls are very thin till near the termination of the layers when they are moderately thickened, and numerous, exceedingly strong acanthopores are abruptly developed. Perforated diaphragms occur sparingly, and the walls occasionally show long narrow swellings.

The peculiar growth, thin walls, and intermittent character of the zoarium, are the most marked features of the species.

Position and locality: Keokuk group, Warsaw, Ill.

STENOPORA TUBERCULATA Prout.

Flustra tuberculata Prout. 1859. Trans. St. Louis, Acad. Sci. Vol. I. p. 447.

Cyclopora polymorpha Prout. 1860. Trans. St. Louis Acad. Sci. Vol. 1, p. 578.

Cyclopora polymorpha Prout. 1866. Geol. Sur. Ill. Vol. II, p. 421. Pl. XXI. fig. 5,5b.

Pl. XVII, fig. 3–3f.

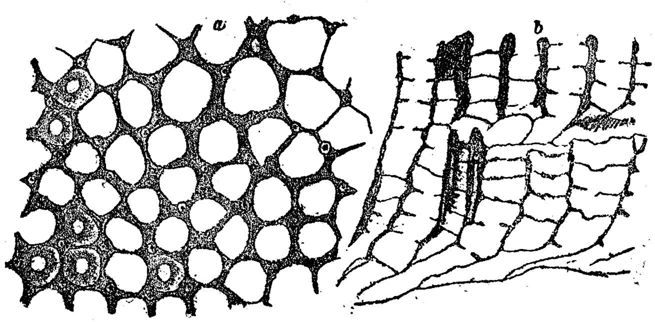

Fig. 17. Sections of *Stenopora tuberculata* Prout x18.
a.—Tangential section; *b.*—Vertical section showing thickness of layers and tabulation of zoœcial tubes.

Zoarium an expanded crust attached to Brachiopoda and other organisms, frequently attaining a large size by superimposing of numerous thin layers; sometimes hemispherical, discoidal, or laminar, and apparently free, with a rugose epitheca upon the lower side. Surface smooth or with faintly marked, scarcely elevated, clusters of cell apertures but little larger than the average. Apertures polygonal, quite regularly arranged, about ten of the average size in three mm., separated by thin interspaces, spinose at the angles. Zoœcial tubes for a short distance prostrate, then curving rapidly to proceed direct to the surface of the layer. Walls thin, somewhat flexuous, often distinctly moniliform. A few mesopores may occur near the center of the clusters mentioned. Diaphragms abundant, perforated, from one-half to their diameter apart. Acanthopores abundant of moderate size, often encroaching upon the visceral cavity.

The variable form of growth, thicker walls and more numerous diaphragms, discriminate this species from *S. emaciata*, while the more decidedly moniliform walls, thinner zoarial layers, slightly larger zoœcia, and smaller acanthopores, separate it from *S. cestriensis*. I cannot distinguish from this species Prout's *Cyclopora polymorpha*, described from the Chester group and propose to unite them as above.

Position and locality: Chester group, Chester and numerous other localities in Illinois; also common in the Warsaw beds, which furnished the original examples of the species, and in the St. Louis limestone.

STENOPORA CESTRIENSIS Ulrich.

Pl. LXXIV, fig. 7,7a.

Zoarium forming laminar expansions of considerable breadth, the under surface provided with a thick concentrically wrinkled epitheca. The typical example consists of but a single layer with an average thickness of about five mm. Celluliferous surface spinulose where well preserved, with low broad tubercles occupied by cell apertures slightly larger than the average; centers of monticules three or four mm. apart. Zoœcial apertures sub-circular or polygonal, about eleven in three mm. Immature portion of zoœcial tubes short, prostrate, bending rather quickly and proceeding direct to the surface. Walls thickened, but seldom appearing distinctly moniliform, the swellings usually being merged into each other. Divisional line between zoœcia sharply defined. Mesopores probably absent. Diaphragms abundant, close set, five or six in one mm. Central perforation large, often closed with a flat or concave plate. Acanthopores numerous, rather large, usually situated at the angles and bulging a little into the zoœcial cavity. They appear more than usually conspicuous in tangential sections, being sharply defined and the dark central spot comparatively large.

This species is related to *S. tuberculata* Prout, but the cells are smaller, their individual walls more clearly defined, the acanthopores more conspicuous, and the zoœcial layers at least twice as thick.

Position and locality: Chester group, Chester, Ill.

STENOPORA RAMOSA Ulrich.

Pl. LXXIII, fig. 6, 6c.

Zoarium ramose, consisting of cylindrical or somewhat compressed stems from five to ten mm. in diameter. Surface usually even but marked with clusters of cells a little larger than the average. Zoœcial apertures angular or sub-circular, frequently preserving the perforated opercula, separated by thin interspaces, about nine or ten in three mm. Zoœcial tubes proceeding in a very gradual curve to the surface where they are almost direct. Walls of zoœcia very thin and flexuous in the axial region, considerably thickened in the peripheral region where they are more or less regularly moniliform, the swellings, however, not separated by very thin intervals. Divisional line between adjoining zoœcia generally well defined. Diaphragms horizontal, with a sub-central perforation, having a thickened margin, rather more than one-half their diameter apart, developed mainly in the cortical region. Mesopores oval, very few. Acanthopores of moderate size, situated generally at the angles, occasionally projecting into the zoœcial cavity.

Sections of a single example show what may be rather large communication pores. In tangential sections they appear as simple transverse lines of lighter color than the walls. In vertical sections they are again represented by narrow light intervals, traversing the walls in a direction parallel with the $\wedge$-shaped layers of sclerenchyma.

Position and locality: Chester group. Common at Sloan's Valley, Pulaski Co., and other localities in Kentucky. Several illy preserved specimens from Chester, Illinois, are supposed to belong here.

STENOPORA MEEKANA Ulrich.

Pl. LXXIII, Fig. 7-7a.

Zoarium ramose, consisting of robust branches, fifteen mm. or more in diameter. Surface without monticules but marked with clusters of cell apertures about one-third larger than the average size. Apertures angular, with thin interspaces, about nine of the ordinary size in three mm. Zoœcial tubes curving gradually from the axial region, direct in the peripheral region. Walls thin and irregularly flexuous in the axial region, thickened and more or less moniliform in the cortical region. Divisional plane between adjoining zoœcia, marked by lighter colored tissue or a dark line. A few thin diaphragms are developed as the tubes approach the mature region. Here they are somewhat thicker, and close set, about two-thirds of a tube diameter apart, and, as usual, perforated subcentrally. Mesopores very few or wanting. Acanthopores not very large, numerous, almost all the angles being occupied.

The far more robust habit of growth, larger number of acanthopores, and somewhat thicker walls, are peculiarities which easily distinguish this species from *S. ramosa*. In other respects they are practically identical, and I do not doubt that they have been developed from a common type.

Position and locality: Chester group, Chester, Ill.

Stenopora rudis Ulrich.

Pl. LXXII, Fig. 8-8b.

Zoarium consisting of hollow irregular branches, varying in size and composed of one or several superimposed layers, each 1.5 mm. or less in thickness. Surface smooth, but with well marked, scarcely elevated, clusters of cells, about one-half larger than the average size. Apertures polygonal, those of the average size 0.3 mm. in diameter, and eight in 3 mm. Zoœcial tubes oblique and thin walled at first, then making an abrupt bend, proceed directly to the surface, the walls at the same time becoming much thicker. One to three bead-like swellings succeed the first. Two to five perforated diaphragms intersect the tubes of each layer, the first occurring at the point where the tubes bend outward. Rather small acanthopores occupy less than half of the angles of junction between the zoœcia. Divisional line between the walls of adjoining zoœcia well marked.

This species makes a close approach to *Anisotrypa*, but the acanthopores ally it rather more closely with *Stenopora*. Sections have a general resemblance to those of S. *polymorpha* Prout, but the zoœcia are larger and the acanthopores less numerous. The hollow branches and large cells distinguish it from the Keokuk species of the genus.

Position and locality: Chester group. Sloan's Valley, Pulaski Co., Ky.

STENOPORA CARBONARIA Worthen.

Pl. LXXIII, Fig. 8-8a.

Chætetes ? carbonaria Worthen, 1875. Geol. Sur. Ill., Vol. 6, p. 526. Pl. XXXII, Fig. 5.

Stenopora carbonaria Foerste, 1887. Bull. Sci. Lab. Denison Univ., Vol. 2, p. 85. Pl. VIII, Fig. 13a-c.

Zoarium ramose, consisting of sub-cylindrical branches, varying in diameter from ten to fifteen mm. Surface smooth, not exhibiting groups of cells marked by differing from the average size. Zoœcial apertures angular and sub-circular, with either thick or thin interspaces, about ten or eleven in three mm. Walls of zoœcial tubes moniliform in the cortical region, the swellings irregular, often merged into each other, at other times separated by a thin interval; twelve to fourteen in two mm. Thin centrally perforated diaphragms developed in the mature zoœcia and about a tube diameter apart; none were observed in the axial region. Mesopores almost wanting. Acanthopores large, fairly numerous. The divisional line between the thickened portions of the walls of adjoining zoœcia is marked by a series of minute dark spots.

The above describes the typical form of the species. Associated with them are a number of other specimens offering certain peculiarities that, while not very marked, are nevertheless sufficient for identification. These I propose to designate as varieties *maculosa* and *conferta*.

var. MACULOSA Ulrich.

Pl. LXXIII, Fig. 10-10a.

This differs from the typical form in having well-marked groups of small cells, surrounded by zoœcia apertures of larger size than the average. Nine or ten of the ordinary size in three mm. The diaphragms are also stronger and more numerous. The branches too are generally somewhat stronger, being sometimes as much as twenty-five mm. in diameter.

var. CONFERTA Ulrich.

Pl. LXXIII, Fig. 9-9a.

This variety has the beads of the moniliform walls more closely set, there being in the peripheral region ten or eleven in one mm. The moniliform character of the walls is more pronounced in this variety than in any other form of the genus known to me, excepting *S. ohioensis* Foerste, lately described from the base of the Coal Measures in Ohio. Should it prove upon further examination that the var. *conferta* is identical with the Ohio form, then Mr. Foerste's name will take precedence over mine.

Position and locality: Coal Measures; both the varieties and the typical form, occur at Caseyville, Ill. I have also studied examples from Ohio. and from Lawrence, Kansas.

STENOPORA? SIGNATA Ulrich.

Pl. LXXIII, fig. 5, 5b.

Zoarium consisting of branching cylindrical stems, from four to seven mm. in diameter. Surface hirsute, without monticules Zoœcial apertures small, sub-circular or sub-polygonal, varying in diameter from 0.15 to 0.25 mm.; about seven in two mm. Interspaces moderately thick, minutely granulose between the strong acanthopores which occur at many of the angles. Zoœcial tubes curving gradually from the center of the axial region to the surface, where they are direct. Walls thin in the axial region, considerably and irregularly thickened in the cortical region, never distinctly moniliform. Diaphragms entirely wanting. Acanthopores very large, about one to every two zoœcia. Sections present a peculiar feature. In tangential sections, for instance, the zoœcial cavity is surrounded by a single series of very minute dark spots. Along the middle of the partition between the zoœcia the same kind of spots form closely arranged stellate clusters, of five or more, while a single series again surrounds the acanthopores. In vertical sections these peculiar spots are closely arranged in transverse series and less regularly in vertical rows. At the surface they appear as granules. I am unable to offer a satisfactory explanation of these singular structures. It is possible, however, that they represent the foundations of delicate setæ. Similar structures have been detected in *Bactropora simplex* and in species of *Rhombopora* (*e. g. R. crassa.*) The minute dark spots between the walls of the zoœcia in *S. montifera* and other species of the genus are probably of the same nature.

The generic reference of the species is somewhat doubtful, and there is little danger of confounding it with any species of *Stenopora* known to me. The large acanthopores serve amply in distinguishing specimens from *Rhombopora crassa* Ulrich, an associated form.

Position and locality: Coal Measures. The only examples seen are from Caseyville, Ill.

Anisotrypa Ulrich, 1883.

(Jour. Cin. Soc. Nat. Hist. Vol. VI, p. 275.)
(For generic diagnosis see page 376.)

When I proposed this genus I supposed the hollow branches and the large cell which occurs at sub-regular intervals among the ordinary zoœcia of *A. symmetrica*, were characters of generic importance. My acquaintance with *Stenopora* Lonsdale, and *Rhombopora* Meek, at that time also was limited. Now, since I have gone over the ground much more fully, I find that both features are really of only specific importance. That I failed to grasp the more significant characters is to be credited to my ignorance of the close relationship existing between *Anisotrypa* and *Stenopora*. This relation seems quite remote when we compare only the typical species of the genera, but becomes rapidly less distant with the extension of our comparisons, so that now the only structures that are not common to the two genera are the acanthopores. These are wanting in *Anisotrypa* Another peculiarity that may hold good for the genus is the ridge-like form of the interspaces separating the zoœcia apertures. The affinities with *Rhombopora* Meek, will be discussed in my remarks upon that genus.

Six species are known to me at this time, the oldest being from the Keokuk group in Lincoln county, Kentucky, and is described as *Rhombopora elegantula* in my "Am. Pal. Bry." It agrees in all essential respects with *A. symmetrica*, and like that species, has occasional large cells. Two species, the *A. fistulosa* and *ramulosa*, belong to the St. Louis group. They are remarkably alike in tangential sections, but the first grows in irregular hollow branches, while the second forms small solid ramulets. Two species differing from each other in precisely the same manner, and from the St. Louis forms, by their much thicker walls and somewhat smaller cells, occur in the Chester group. The one I have called *A. solida*, the other must await an opportunity for publication. The sixth species is *A. symmetrica*, the type of the genus. It is not uncommon at several Chester localities in Kentucky, and I have also seen specimens from Illinois, that were collected by Mr. J. M. Nickles at Chester. A good example is figured on Pl. LXXII, fig. 5, to show the general arrangement of the zoœcia and the distribution of the larger cells.

ANISOTRYPA FISTULOSA Ulrich.

Pl. LXXII, fig. 6–6c.

Zoarium composed of from one to three layers, each about one mm. in thickness, assuming the form of very irregular, branching hollow stems, from less than five mm. to more than ten in diameter. Inner side lined with a finely wrinkled epitheca. Surface generally smooth, at intervals of three or four mm. with clusters of apertures of larger size than the average, which in rare instances are slightly elevated. A few small cells usually present near the centers of the clusters. Apertures regularly arranged, polygonal, commonly hexagonal, varying in diameter from 0.28 mm. to 0.5 mm., in the clusters, nine or ten of the average size in three mm., separated by comparatively thin partitions. Zoœcial tubes curving gently throughout their lenght, not quite direct even at the surface of the layers. Walls thin and flexuous below, but towards the surface they become rather abruptly, but only moderately thickened. Lines between walls of adjoining zoœcia sharply marked. Mesopores (?) (small tubes) very rare, only in the groups of large zoœcia. Diaphragms with rather large perforations, three or four in each tube, quite commonly observed closing their apertures.

This fine species is readily distinguished from *A. symmetrica* (a Chester species) by the thinner walls and in having groups of large cells instead of one or two zoœcia of very large size.

Position and locality: St. Louis group, Pella, Iowa. A similar species, having somewhat smaller cells, occurs in the Chester limestone.

ANISOTRYPA RAMULOSA Ulrich.

Pl. LXXII, fig. 7, *7a*.

In its minute structure this species closely resembles *A. fistulosa*, from which it may be distinguished by its consisting of small solid branches, from three to six mm. in thickness. The cell apertures are about of the same size and shape, though, perhaps always, separated by slightly thicker walls, and there are clusters of large sized apertures. The minute structure of the walls and the arrangement of the perforated diaphragms in the mature region are not materially different. Vertical sections will of course be distinguished immediately by the solid axis of the present species. The zoœcial tubes in the axial region have very thin walls, and so far as observed are not crossed by diaphragms.

Position and locality: St. Louis group. Pella, Iowa.

ANISOTRYPA SOLIDA Ulrich.

Pl. LXXII, fig. 9-*9e*.

Zoarium consisting of solid cylindrical stems, branching dichotomously and otherwise. The examples from Sloan's Valley, Ky., average three mm. in diameter, those from Chester, Ill., nearly five mm. Surface with clusters of cells a little larger than the average, which are only conspicuous when they are slightly elevated. Zoœcia polygonal, usually hexagonal, varying in width from 0.28 to 0.45 mm. in the clusters, nine or ten of the average size in three mm. Apertures oval or subcircular, rarely angular. Zoœcial tubes curving gradually from the axial region to the surface where they are direct. Walls thin in the axial, very much thickened in the narrow cortical region, where they may present one or two faint constrictions. Adjoining zoœcia separated by a well marked divisional line. Interspaces thick and ridge like. Three or more perforated diaphragms intersect the tubes in the mature region. Dark spots appear in tangential sections at the angles of the zoœcia which simulate acanthopores, but are not of that nature so far as I can make out.

The solidity of the stems is the character that separates this form readily from *A. symmetrica*, the type of the genus, figured on Pl. LXXII, fig. 5; it also lacks the single very large aperture at the centre of the clusters, which is such a characteristic feature of that species. The much thicker interspaces distinguish the species from *A. ramulosa*.

Position and locality: Chester group. Sloan's Valley, Pulaski Co., Ky., and Chester, Ill.

AMPLEXOPORA Ulrich, 1882.

("Am. Pal. Bry." Jour. Cin. Soc. Nat. Hist. Vol. V, p. 154.)

(For generic diagnosis see page 377.)

Fourteen species of this genus, ranging in time from the Trenton to the Hamilton group, have been studied by me. The two here described have thinner walls than is usual in the genus, differing in that respect conspicuously from *A. cingulata*. Still they present all the essential characters of *Amplexopora*, and are brought into closer connection with the typical species than at first appears by such intermediate forms as *A. superba* Foord, *A. septosa* and *A. robusta* Ulrich. In their general structure species of *Amplexopora* resemble ramose species of *Stenopora* Lonsdale, but are fundamentally distinguished by the opercular structures, perforated diaphragms, and periodically constricted zoœcial walls of that genus.

AMPLEXOPORA AFFINIS Ulrich.

Pl. XXXVI, fig. 2-2*a*.

Zoarium irregularly dendroidal, branching seldom, about fifteen mm. in thickness. Surface smooth, exhibiting scarcely appreciable clusters of cells slightly larger than the average. Cell apertures subpolygonal. Zoœcial tubes polygonal, thin-walled, seven or eight in two mm. Diaphragms somewhat more than a tube diameter apart in the axial region, in the peripheral region about twice as close. A few infundibular diaphragms scattered about promiscuously. Acanthopores conspicuous, usually situated between the zoœcia, projecting more or less into one or the other zoœcial cavity, occasionally situated at the angles.

The affinities of this species are with *A. septosa* Ulrich, but its thinner walls, less numerous acanthopores, and more robust growth easily separate it from that form.

Position and locality: Cincinnati group. Wilmington, Ill.

AMPLEXOPORA PUSTULOSA Ulrich.

Pl. XXXVI, fig. 3-3*e*.

Zoarium subramose, lobate or irregularly compressed, of an average thickness of eight mm. Surface rarely smooth, generally set with low monticules, about 2.6 mm. apart from center to center, consisting of groups of larger cells with a few small ones. Zoœcial walls a little flexuous, thickened somewhat in the cortical region. Zoœcia polygonal, hexagonal and pentagonal, about nine in two mm. Apertures subpolygonal, those in the monticules one-half larger than the others. In the axial region the diaphragms are about twice their diameter apart, but become more numerous as the peripheral region is reached, where they are somewhat less than a tube diameter apart. Acanthopores fairly numerous, commonly situated at the angles. Usually there are two or three superposed mature regions with diaphragms very crowded where the transition from one to the next takes place.

This species differs in several important respects from *A. septosa* Ulr. In that species acanthopores are more numerous and project into the visceral cavity, tubercles are wanting or but slightly elevated and the growth is strictly ramose.

Position and locality: Cincinnati group. Hanover, Clarksville, and other localities in Ohio; probably occurs at Wilmington, Ill.

MONOTRYPELLA Ulrich, 1882.

("Amer. Pal. Bry." Jour. Cin. Nat. Hist. Vol. V, p. 153.)

(For generic diagnosis see page 377.)

Species of this genus closely resemble *Amplexopora* and *Homotrypa*, but with a little practice it is not difficult to distinguish between them. The absence of acanthopores separates them from the first, and the absence of cystiphragms from the second.

True mesopores are also wanting, but in several species, notably *M. crassimuralis* and *M. subquadrata*, the zoœcial walls are partially separated near the surface by tabulated interspaces.

MONOTRYPELLA CRASSIMURALIS Ulrich.

Pl. XXXVIII, fig. 2, 2f.

Zoarium dendroid, dividing dichotomously or otherwise at intervals from ten to eighteen mm.; branches with low rounded monticules, whose centers are about two mm. apart. Zoœcial tubes after passing through the axial region with a steady curve, open at the surface with direct circular apertures, 0.1 mm. in diameter, arranged in regular curved series, about eight in two mm. Interspaces thick, flattened centrally, then sloping down to the zoœcial cavities; thickest on the monticules, where a few illy defined mesopores are generall distinguishable. Tangential sections vary considerably in the appearance of the interspaces, sometimes showing open spaces of diverse form and size between the ring-like walls of the zoœcia, (see Pl. XXXVIII, fig. 2c); at other times the interspaces seem to be filled with a light colored calcareous deposit. In transverse sections the tubes in the axial portion of a branch are very thin walled and regularly rhomboidal or pentagonal. Diaphragms wanting in the axial, very few in the mature region; numerous and thick in the interspaces.

This species belongs to the same section of the genus as *M. quadrata* Rominger, and *M. subquadrata* Ulrich, though differing very obviously from them. All three agree in having the tubes in the axial region regularly rhomboidal. Another peculiar feature is the habit of changing the direction of the rhombs at intervals of about one mm. This peculiarity is readily noticed in rough vertical fractures, which exhibit concentric, alternately smooth and rough or toothed spaces, each about one mm. wide. In thin vertical sections each change is marked by the origin of a number of rapidly enlarging young tubes.

The most striking feature of the species is the extreme thickness of the interzoœcial spaces. This character alone readily distinguishes the species from its nearest allies.

Position and locality: Cincinnati group, Wilmington, Ill.

MONOTRYPELLA APPRESSA Ulrich.

Pl. XLIV, fig. 1–1d.

Zoarium consisting generally of very much flattened branches, occasionally sub-cylindrical. Surface smooth, with clusters of cells larger than the ordinary size, little, if any, elevated, three mm. apart measuring from center to center. Apertures of zoœcia thin-walled, polygonal, varying in diameter from 0.2 to 0.35 mm. In the axial region the walls of the zoœcia are very thin, but become thickened in the cortical region. In tangential sections prepared since the plates were printed the median region of the walls exhibit a minutely granular aspect. Zoœcial tubes curve but slightly and are still oblique in the peripheral region, though the apertures appear to be direct; about seven of the ordinary zoœcia in the space of two mm. Three or four horizontal or but slightly curved diaphragms are developed in the transition period of the zoœcial tubes.

M. pulchella Edwards and Haime, from the Wenlock limestone of Dudley, England, has some affinities to this form, but has much larger and more angular zoœcia, with comparatively thinner walls; the tabulation also differs. The species here described approaches more nearly to *M. æqualis* Ulrich, from the Cincinnati group of Ohio, the type species of the genus, but has thicker walls, a much smaller number of diaphragms that are also differently situated; and the zoœcial tubes are oblique in the peripheral region, while in *M. æqualis* they are direct.

Position and locality: Hamilton group; Rock Island, Illinois, and Davenport, Iowa.

PETALOTRYPA Ulrich.

(For generic diagnosis see page 377.)

The bifoliate zoarial habit of this genus marks a decided and easily recognized departure from *Amplexopora*, *Monotrypella* and *Leptotrypa*, while in the zoœcial features it is about equally related to all of those types.

PETALOTRYPA COMPRESSA Ulrich.

Pl. XLVI, fig. 4—4f.

Zoarium consisting of compressed branches, two or more cm. in height, one cm. or less in width, and form one to four mm. in thickness. Surface smooth, with scarcely appreciable clusters of cell apertures a very little larger than the average, and with somewhat wider interspaces. Zoœcial tubes almost direct from the medial plane, the prostrate portion very short. Walls of moderate thickness throughout. Zoœcia sub-polygonal, at times quite regularly hexagonal, about eight in two mm. The number of mesopores varies in different examples; disposed to congregate in the clusters. Diaphragms abundant in the zoœcia, situated at rather unequal distances apart; in the mesopores more closely set. Dark spots simulating acanthopores, or perhaps really of that nature, found at some of the angles between the zoœcia. Between two adjoining zoœcia there is a dark line which is interrupted by tissue of the same color as the wall substance. I am not prepared to give the exact interpretation of this feature.

This species neither superficially nor internally can be confused with any other species known to me from Devonian rocks. Very frequently specimens are overgrown by a form of *Aulopora* often causing the subsequent growth to be very irregular.

Position and locality: Hamilton group; Davenport, Iowa; Rock Island, Ill.

PETALOTRYPA DELICATA Ulrich.

Pl. XLVI, fig. 5—5a.

Zoarium a slightly undulated bilaminar frond, about two cm. in height, the same in width, and 0.7 mm. in thickness. But two examples of this species have been examined. Surface smooth; cell apertures angular, subrhomdoidal or hexagonal, arranged in diagonally intersecting series, about nine in the space of two mm. measuring diagonally. Zoœcial tubes very short, approaching the surface in a steady curve. An occasional diaphragm present at the beginning of the cortical region. Acanthopores absent, though at some of the angles of the zoœcia are dark spots which may be of that nature.

Its very much thinner zoarium, the rhombic cell apertures, their regular arrangement and the almost total lack of diaphragms discriminate this form from *P. compressa*.

Position and locality: Hamilton group; Buffalo, Iowa and Rock Island, Ill.

LEPTOTRYPA Ulrich, 1883.

Am. Pal. Bry. Jour. Cin. Soc. Nat. Hist. vol. VI, p. 158.

(For generic diagnosis see page 377.)

My original diagnosis of this genus included only thin parasitic zoaria, but later investigation has shown that these could not be separated from several species that differed only in the thickness and ultimate form of the colony. The zoœcial features are identical in the massive and parasitic forms, nor is there any difference in the general plan of construction.

The massive and discoid species present great resemblance to *Monotrypa* Nich., but good tangential sections serve to distinguish the genera at once, acanthopores being a conspicuous feature in sections of *Leptotrypa*, while such structures are wanting in *Monotrypa*. In all about seventeen species of *Leptotrypa* are known to me from American Palæozoic rocks; of these one (*Chætetes quadrangularis* Nich.) or perhaps two occur in the Hamilton group, two in the Niagara, and the rest in the Cincinnati and Trenton groups. The four species here described are fair representatives of this genus.

LEPTOTRYPA HEXAGONALIS Ulrich.

Pl. XXXVI, Fig. 6-6a.

Zoarium forming parasitic expansions less than one mm. in thickness, spread upon *Orthoceras* or *Hyalithus*. Surface smooth. Clusters of cell apertures of almost twice the usual size are arranged in diagonally intersecting rows; these clusters are about three mm. apart, measuring from center to center. Zoœcia regularly hexagonal in shape, sometimes a little elongated, seven measuring longitudinally, almost nine, diagonally, in two mm., diameter of the smaller 0.2, of the larger 0.35 mm. Acanthopores prominent on the surface when well preserved.

The thin parasitic growth and markedly hexagonal cells are the most noticeable features of this species.

Position and locality: Trenton group, Mineral Point, Wis.; Calhoun Co., Ill.; and Minneapolis, Minn.

LEPTOTRYPA FILIOSA D'Orbigny.

Pl. XXXVI, Fig. 7-7a.

Monticulipora filiosa D'Orb., 1850. Prod. de Pal. t. I, p. 25.

Chætetes filiosa Ed. & H., 1851. Pol. Foss des Terr. Pal., p. 261.

Chætetes filiosa ? Nich., 1875. Pal. Ohio, vol. II, p. 206.

This species is a very common one in the Cincinnati group at Cincinnati, Ohio. It is massive in shape, sometimes attaining a vertical thickness of thirty cm. or even more. The zoœcial tubes are regularly prismatic, seven or eight in two mm., with groups of larger size. Diaphragms something over a tube diameter apart, but become about twice as close-set as the zoœcial tubes near the top of a mature region. Acanthopores few and inconspicuous, only present in the mature regions, therefore only rarely met with in tangential sections. Mature region very short. Many successive mature and immature regions may be observed upon some specimens, the tubes usually being continuous throughout the zoarium. The sections figured were taken from a small specimen from the Trenton group of Calhoun Co., Ill. This is the first time this species has been recorded from so low a horizon.

LEPTOTRYPA STIDHAMI Ulrich.

Pl. XXXVI, Fig. 4-4b.

Zoarium irregularly lobate-massive. Surface smooth, with clusters of somewhat larger cell apertures. Zoœcial tubes radiating out in all directions from a point in the base, angular, irregular in shape, and thin-walled even to the surface, from eight to ten in two mm. Diaphragms horizontal, about a tube diameter apart. Acanthopores rather large, numerous, situated at the angles of the zoœcia.

The shape of the zoarium and the number and regularity of the diaphragms, combined with the size and number of acanthopores, are the main distinguishing features of this species.

The specific name is given in honor of Rev. I. F. Stidham, to whose generosity I am indebted for the type specimens.

Position and locality: Cincinnati group, Brown Co., Ohio.

LEPTOTRYPA SEMIPILARIS Ulrich.

Pl. XXXVI, Fig. 5-5d.

Zoarium small, massive. but varying in shape from lenticular to subglobose; usually hemispherical. Surface smooth or with low broad elevations having a cluster of larger cells at their apices. Zoœcial tubes direct, thin-walled throughout, with subpolygonal apertures, about eight in two mm. Diaphragms usually wanting, occasionally a few developed as the tubes approach the surface. Acanthopores of moderate size and number, situated at the angles of the zoœcia.

The greater regularity and slightly larger size of the zoœcia, the different shape of the zoarium, and the almost total absence of diaphragms distinguish this species from *L. stidhami*, its nearest congener.

Position and locality: Cincinnati group, Covington, Ky., about 300 feet above the bed of the Ohio river.

DIPLOTRYPA Nicholson, 1879.

(Pal. Tab. Corals, p. 292.)

(For generic diagnosis see page 378.)

In the general aspect and composition of the zoarium this genus presents much resemblance to *Prasopora* Nich. and Ethr. Jun. The absence of true cystiphragms, however, is an important and easily recognized peculiarity, that not only distinguishes the two genera, but also casts much doubt upon the family relations of *Diplotrypa*. Such species as *D. whiteavsi* Nich., and *D. milleri* Ulr., point to decided affinity with the CALLOPORIDÆ. On the other hand *D. regularis* Foord, *D. infida* and *D. patella* Ulr., approach more nearly to *Prasopora*. In this group of species the zoœcial tubes are crossed by oblique, more or less recurved, or occasionally even overlapping diaphragms. In the last instance they simulate isolated cystiphragms in a marked degree, but a careful examination has failed to show that they are anything else than irregular or modified diaphragms, since in no case have I detected the unmistakable appearance of cystiphragms in tangential sections.

D. petropolitana, the type of the genus and one or two similar but as yet undescribed species, seem to be very different from the other species now classed under *Diplotrypa*. In fact I regard them as more nearly related to *Monotrypa* and *Batostoma*, two genera constituting with the typical section of *Diplotrypa* the provisionally established family DIPLOTRYPIDÆ. The ultimate position of these genera, however, depends largely upon the results of future study and discoveries.

DIPLOTRYPA PATELLA Ulrich.

Pl. XXXIII, fig. 2-2c.

Zoarium lenticular; the typical specimen is twenty-five mm. across, another larger example thirty-eight mm. across; greatest thickness, at centre, from two to four mm. Surface smooth, thinly hirsute from the surface projections of the acanthopores, showing clusters of cells larger than the average, but not elevated above the general level. Under surface provided with a thin and somewhat concentrically wrinkled epitheca. Zoœcia very thin walled, about eight in two mm. Apertures circular, sometimes polygonal, those of the normal size about 0.18 mm., the larger 0.25 mm. in diameter, arranged in diagonally intersecting series. Usually each zoœcium is touched by four others, with an acanthopore situated at or very near the point of contact. The interspaces between the zoœcia are occupied by mesopores, bounded by three or four concave sides, Mesopores more numerous in the clusters of larger cells. In the zoœcial tubes diaphragms are moderately abundant, straight, at times curved, especially in the lower part of the tubes where they frequently have the appearance of cystiphragms and may actually be of that nature. In the mesopores the diaphragms are closely set, about three in the space of a tube diameter.

The nearest congener of this form is possibly the *D. regularis* Foord, from which it differs in having the mesopores larger, and a much larger number of diaphragms in the tubes and other less important features.

Position and locality:—Cincinnati group, Oxford, Ohio, and other localities.

Diplotrypa? dubia Ulrich.

Pl. XXXIII, fig. 3-3b.

Zoarium discoidal. Upper surface with the usual style of cell aperture; lower surface with an epitheca. Zoœcial walls slightly wavy. Zoœcia direct, circular, seven or eight in two mm. Mesopores comparatively few, small, situated at the angles between the zoœcia. Diaphragms horizontal in the zoœcial tubes, their diameter or more apart, closely set in the mesopores. Acanthopores wanting.

As shown in fig. 3*a*, the zoœcial walls have a peculiar intermittent structure, which seems conclusive evidence of the walls having been originally minutely porous.

The small size and number of the mesopores make it somewhat doubtful whether this species is properly referred to *Diplotrypa*. This character and the absence of acanthopores distinguish it from other described species of the genus.

Position and locality:—Cincinnati group, Wilmington, Ill.

Batostoma Ulrich, 1882.

("Amer. Pal. Bry." Jour. Cin. Soc. Nat. Hist., vol. V, p. 154.)

(For generic diagnosis see p. 379.)

Such species of the genus as *B. implicatum* Nich., and *B. jamesi* Nich., are characterized by zoœcia with thick ring-like walls, irregularly oval apertures, numerous mesopores and acanthopores. Although a closely allied species, *B. variabile* Ulr., differs conspicuously from them in having few mesopores, and polygonal zoœcia. *B. fertile* Ulr., a species from the Trenton shales of Minnesota, differs in the same way, but goes farther in having acanthopores considerably reduced in size. Two undescribed forms deviate from the typical species in very much the same manner, and in one of them both the mesopores and acanthopores are so much reduced in number that they are practically wanting. Through these species the genus is made to resemble *Monotrypella* and *Amplexopora* without, however, there being any very intimate relationship. The true position of the genus is between *Diplotrypa* and *Monotrypa*.

A peculiar group of species comprises *B. imperfectum* Ulr., *B. irrasum* Ulr., and *B. ottawense* Foord. These differ from the other species in having incomplete diaphragms, and ought, perhaps, to constitute a distinct genus.

BATOSTOMA VARIABILE Ulrich.

Pl. XXXV, fig. 4-4*e*, 5, and Pl. XXXVI, fig. 1.

Zoarium exceedingly variable; encrusting, lobate, digitate, ramose, and subfrondescent. Surface smooth, showing inappreciably elevated clusters of larger cells. Walls of zoœcia in axial region thin, faintly and irregularly flexuous; much thickened in the mature region; the tubes are polygonal, approach the surface with a gradual curve, and are mainly in contact, with the divisional line between those adjoining sharply marked. Apertures angular, averaging six in two mm. Mesopores angular, varying in number, generally few as in the sections figured. Diaphragms few in the immature region, three or four in the narrow cortical region, the one or two nearest the surface concave; in the mesopores they are moderately abundant. Acanthopores fairly numerous, usually situated at the angles between the zoœcia.

The name "*variabile*" is given to this species because different examples exhibit considerable variations in the mode of growth, in the number and arrangement of the mesopores, in the amount of thickening of the walls in the cortical region, and some other features.

This form bears much resemblance to the *B. jamesi* Nich., which, however, has oval zoœcia separated by many mesopores, while this species has the zoœcia polygonal and often in contact, with fewer mesopores and diaphragms.

Position and locality:—A very abundant and characteristic species of the upper beds of the Cincinnati group. It is found at numerous localities in Ohio and Indiana, and at Savannah, Ill., and Delafield, Wis.

BATOSTOMA IMPERFECTUM Ulrich.

Pl. XXXV, fig. 3-3*d*.

Zoarium ramose, branches subcylindrical, very robust, twenty mm. or even more in thickness, dividing at short, irregular intervals. Surface marked with very slightly elevated aggregations of larger cells surrounding a larger or smaller cluster of mesopores, about three mm. apart. Zoœcial walls but little thickened in the peripheral region. Mature portion of the zoœcial tubes usually longer than the immature portion; the bend in the tubes is rather abrupt. Zoœcia subpolygonal, about seven in two mm., with subcircular apertures; the diameter of the smaller apertures is about 0.2 mm., of the larger, constituting the borders of the clusters, about 0.35 mm. A few mesopores scattered about irregularly among the zoœcia, usually gathered into clusters of from six to fifteen in the centre of a group of the larger sized zoœcia. Diaphragms present throughout the zoœcial tubes, some horizontal, some incomplete, varying in separation, in the axial region somewhat more than a tube diameter distant, in the cortical region from one-third to one-half of a tube diameter apart. Acanthopores (?) very small.

Sections of this form present some very interesting features. In the axial region the diaphragms extend horizontally across the tubes but in the mature region, they are incomplete and crescentic in shape, rarely, if ever, extending more than half way across the tube. In tangential sections another peculiarity is brought out, namely, at the angles between the zoœcial tubes, there is a space, generally triangular in shape, of lighter color than the remainder of the interspaces or wall. The points of these spaces continue as dark lines that mark the divisional line between the walls of adjoining zoœcia. The walls exhibit a horizontally lined appearance reminding one very much of the wall structure observed in some of the CERAMOPORIDÆ (*e. g. Crepipora*). In exceptionally good tangential sections minute circles may be detected between the zoœcial walls. They have the appearance of minute thin-walled tubuli, and, though much smaller than usual, are probably equivalent to the peculiar acanthopores of this genus.

This species resembles *B. ottawense* Foord, in the possession of incomplete diaphragms and the peculiar structure of the walls, but differs in the closer arrangement of the tubercles, the thinner walls, and inconspicuous acanthopores.

Position and locality:—Cincinnati group, Wilmington, Ill.

MONOTRYPA Nicholson, 1879.

(Pal. Tab. Corals. p. 293.)

(For generic diagnosis see page 379.)

MONOTRYPA RECTIMURALIS Ulrich.

Pl. XXXVIII, Fig. 4-4b.

Zoarium massive, varying from lenticular to sub-spherical in shape, growing to be ten or more cm. in diameter. Surface generally smooth, presenting, occasionally, faintly elevated clusters of cell apertures, about one-half larger than the ordinary size. Zoœcia angular, direct, with exceedingly thin straight walls; apertures polygonal, about six of the average size in the space of two mm. Straight horizontal diaphragms from two to four tube diameters apart. No acanthopores observed. There are indications that the zoarium is built up of a number of successive superposed mature regions with a very narrow immature region, separating two succeeding mature regions.

The simplicity of its structure is the most marked feature of this species. It differs from *M. undulata* Nich., and *M. subglobosa* Ulrich, in having straight instead of undulating or crenulated walls.

Position and locality: The type specimens are from the Cincinnati group, in Alexander Co., Ill. Examples apparently of this species are quite common near Savannah, Ill., and occur more rarely at Cincinnati, Ohio.

CERAMOPORA Hall, 1852.

(Pal. N. Y. Vol. II, p. 168.)

(For generic diagnosis see page 380.)

The type species of this genus is so peculiar in certain respects that I have deemed it advisable to figure its internal structure. This is done on Pl. XXXIX, by fig. 1-1*b*. A brief description of the species is as follows.

Ceramopora imbricata Hall.

Ceramopora imbricata Hall, 1852. Pal. N. Y. Vol. II, p. 169. Pl. 40*e*, fig. 1*a*–1*i*.

Zoarium free, discoidal, plano-convex, under side sometimes slightly concave, from five to fifteen mm. in diameter; thickness at center seldom exceeding four mm., usually only about two or three mm. No epitheca on the lower side. Lower or basal portion of zoarium composed of a cellular or spongy tissue, from which the zoœcia grow out more or less obliquely. At the depressed center of the zoarium the zoœcia are nearly direct, but toward the margin they gradually become more and more oblique. Zoœcia compressed tubular, being long oval in transverse section. Apertures imbricating, arranged in multiplying radial series, all facing away from the center, triangular or oval in outline, 0.5 to 0.7 mm. in their long diameter. Intercellular space occupied by irregularly flexuous rows of mesopores, variously shaped, short. Zoœcial tubes and mesopores communicate rather freely by means of perforations in the walls. Besides the walls have that granular structure which is supposed to indicate an originally minutely porous condition. Lunarium small, yet well marked. No diaphragms developed.

The remarkable features about this species are its free habit, and the spongy basal layer. When compared with the other forms which are generally referred to the genus, it does not seem probable that they are congeneric. The Lower Silurian species I refer to either *Ceramporella* or *Crepipora*. Several of the Upper Silurian forms which Hall has regarded as congeneric with *C. imbricata*, are most probably referable to the Fistuliporidæ, (*Eridopora* Ulr.). The same is believed of *Ceramopora huronensis* Nich., from the Hamilton formation.

Position and locality: Niagara group: Lockport, N. Y. (Hall); Osgood, Indiana.

CERAMOPORELLA Ulrich, 1882.

("Amer. Pal. Bry." Jour. Cin. Soc. Nat. Hist. Vol. V, p. 156.*)

(For generic diagnosis see page 380.)

This genus is intended to receive a number of Silurian Bryozoa that most palæontologists would refer to *Ceramopora* Hall. But, as I have shown, *C. imbricata*, the type of the genus, differs too widely from these forms to admit of being referred to the same genus.

Commencing in the upper half of the Trenton group with one or two species, *Ceramoporella* is represented by six or seven additional species in the Cincinnati group. Only three of these are here described, while Nicholson's *Ceramopora ohioensis* is, provisionally, also placed here. It is questionable whether the genus is represented in Upper Silurian rocks. Some of the species from that horizon, that have been described under *Ceramopora*, present a close external resemblance to *C. distincta*, yet I am inclined to believe that a careful examination of their interiors will reveal Fistuliporoid characters.

CERAMOPORELLA DISTINCTA Ulrich.

Pl. XXXIX, fig. 6, 6*a*.

Zoarium forming thin, parasitic expansions upon Monticuliporoids or Orthocerata; by the formation of successive superimposed layers, large masses may result. The layers vary in thickness from 0.5 to 1.0 mm. Surface even, though sometimes appearing monticulose owing to the zoarium adapting itself to the irregularities of the surface to which it is attached. Zoœcia thin-walled, at first prostrate, then becoming abruptly direct or almost so, more or less triangular or pyriform, and with well marked lunaria. In young examples very oblique, almost imbricating. Apertures with thin obliquely projecting peristome, more elevated posteriorly, oval in shape, about 0.2 mm, in

* A description of this genus was published as above cited in the synopsis of classification that appeared in the first part of my "American Palæozoic Bryozoa." Unfortunately, the publication of this memoir was discontinued ere I could take up the CERAMOPORIDÆ. As no good species of the genus was then described I could not name a type. Hence the genus was not actually established, and ought, perhaps, to date from this work.

their longer diameter, arranged in regular series, about seven or eight in three mm. Mesopores shallow, developed in great numbers, usually arranged in a single or double linear series, between the sides of the zoœcia, occasionally completely isolating a zoœcium. In the fully matured perfect condition their apertures are closed by a thin membrane.

This very pretty species is distinguised by its small cells and rather widely separated zoœcia apertures. Their oval form and the continuation of the peristome around the anterior margin are also quite distinctive.

Position and locality: Cincinnati group. Abundant at Cincinnati, Ohio, especially at the foot of the hills. The same species, or a closely allied form, occurs at Wilmington, Ill.

CERAMOPORELLA STELLATA Ulrich.

Pl. XLI, fig. 1. 1*a*.

Zoarium a thin subcircular crust upon foreign bodies. The only specimen seen is 0.5 mm. in thickness, by about thirteen mm. in diameter. Surface with prominent conical monticules, their summits apparently solid, and about three mm. apart; their sloping sides occupied by radially arranged zoœcia. Zoœcia usually contiguous in the radial series, the series separated by slightly concave furrows which diverge from the centre of the monticules, and impart to the whole a stellate appearance. Apertures very small, oval to subcircular, nearly direct, about 0.12 mm. in diameter, nine or ten in two mm. Hood or lunarium very little developed except near the summits of the monticules. Mesopores very abundant, occupying the centers and rays of the monticules, a few are found in the end spaces also.

The conical monticules and the decided radial arrangement of the zoœcia are such striking features, that I do not hesitate in pronouncing this a very distinct species. It cannot be confounded with any other known to me.

Position and locality: Cincinnati group; Sterling, Ill.

CERAMOPORELLA GRANULOSA Ulrich.

Pl. XLI, fig. 2, 2a.

Zoarium forming masses, consisting of many superimposed layers, the initial layer being attached to some foreign body; in the type specimen a species of *Pachydictya*. Surface even, granulose with groups of larger cells. Zoœcia oval, direct to the surface. Lunarium prominent, narrow, occupying from one-fourth to one-third the circumference of the wall. Apertures somewhat oblique, irregularly oval, from 0.2 to 0.3 mm. in diameter, in diagonally intersecting series, about six in two mm. A considerable number of rather small irregular mesopores are scattered about among the zoœcia. Rather abundant thin diaphragms intersect the tubes. A large number of small dark spots, precisely like acanthopores in tangential sections occur in the walls. Vertical sections, however, show that unlike these structures they do not form continuous thick-walled tubuli, but that they are developed at successive levels corresponding with the diaphragms.

The granules, numerous diaphragms, and less regular arrangement of its parts, distinguish this species from *C. distincta* which it resembles in the size of the zoœcia. I am not acquainted with any other species that would admit of closer comparisons.

Position and locality: Cincinnati group; Wilmington, Ill.

CERAMOPORELLA? OHIOENSIS Nicholson.

Pl. XXXIX, fig. 2. 2a.

Ceramopora ohioensis Nich. 1875. Pal. Ohio, Vol. II, p. 265. Pl. XXV, fig. 10,10e.

Zoarium incrusting, forming thin expansion over other Bryozoa or the shells of Brachiopoda, 0.5 to 1.5 mm. thick, composed, usually, of but a single layer, but sometimes of two or three superposed layers. Surface with slightly elevated clusters of zoœcia of larger size and with thicker walls than usual. Zoœcia at first prostrate then rising abruptly, proceed almost direct to the surface. Walls moderately thick. Apertures varying in shape, but more or less triangular or subromboidal, and oblique on account of the prominent elevation of the overarching lunarium or hood. Zoœcia arranged in obscure radiating series around the elevated clusters, and in diagonally intersecting lines on the spaces between them; here six or seven occur in two mm. The long diameter of the apertures varies from 0.25 to 0.5 mm. in the clusters. A small number of irregular mesopores, about one-fourth as large as the zoœcia, are interspersed among them.

At this time it seems highly improbable that this species is congeneric with *Ceramopora imbricata* Hall. It is more nearly related to *Ceramoporella* and *Crepipora*, and provisionally, I propose to arrange the form as above. It is readily distinguished from typical species of the genus by its rather thick walls and few mesopores.

Position and locality: Cincinnati group. Common at Cincinnati, Ohio.

DIAMESOPORA Hall, 1887.

Diamesopora Hall. Pal. N. Y. Vol. II, p. 158, 1852. (Not defined.)

Cœloclema Ulrich. Jour. Cin. Shc. Nat. Hist. Vol. V, 1882. (Not defined.)

Diamesopora Hall. Pal. N. Y. Vol. VI, p. XV, 1887.

(For generic diagnosis see page 380.)

This name stands for a convenient and easily recognized genus of the CERAMOPORIDÆ. Though already used in 1852, the genus was not defined by Hall until 1887. There are no very marked internal peculiarities, but the ramose form and the hollow branches serve excellently to separate its species from other Ceramoporoids. In these features they resemble *Chilotrypa* Ulr., but thin sections will immediately distinguish them, as that genus is an unqualified member of the FISTULIPORIDÆ, having vesicular tissue instead of untabulated mesopores.

The genus is represented by one undescribed species in the Trenton limestone of Canada and New York, by *D. vaupeli* and *communis* Ulrich, and *D. oweni*, (*Fistulipora oweni* James,) in the Cincinnati group, by *D. oscula*, *infrequens*, *sub-imbricata* *dichotoma*, *tubulosa* and *varia* of Hall* in the Niagara group,

* With the exception of *D. dichotoma*, all these species are described by Prof. Hall as *Trematopora*. A closer examination of these Niagara forms will, I fear, prove that they are not all distinguished by good specific characters.

and by *C. constricta* and *venusta* (*Trematopora constricta* and *venusta* Hall,) in the Lower Helderberg group. Several undescribed forms are known to me, and, so far as I am able to judge from Billings' brief description, his *Helopora circe* and *H. variopora* (Anticosti group) belong here.

DIAMESOPORA VAUPELI Ulrich.

Pl. XXXIX, fig. 3, 3b, and Pl. XLI, fig. 4, 4c.

Zoarium consisting of hollow branches whose diameter varies from two to five mm., the average being about three mm.; thickness of zoarium a mm. or less. Surface even. Axial tube circular, with nearly smooth epitheca. Apertures oval, about 0.18 mm. in their long diameter, arranged in very regular diagonally intersecting rows, ten in three mm. measuring diagonally, with prominent overarching hoods which are all directed toward the distal extremity. Zoœcial tubes at first prostrate along the axial tube, then procumbent upon the next higher zoœcium, then bending abruptly to proceed more or less directly to the surface. Mature portion of zoarium about twice as thick as the immature. Zoœcial walls thin in the axial region, very thick in the mature zone. Lunarium, at the lower or posterior end of each zoœcium, of lighter colored material than the rest of the wall substance. Mesopores small, developed in considerabundance in the mature region. Diaphragms wanting.

This is a very neat and abundant species at the foot of the hills about Cincinnati, O. In the absence of maculæ and other features it resembles some of the Upper Silurian species of the genus, but more closely a small undescribed form occurring in the Trenton limestone of Canada and New York.

The specific name is given as a small compliment to my friend Mr. E. H. Vaupel, who was the first to point out its peculiarities.

Position and locality: Cincinnati group, Cincinnati, O.

DIAMESOPORA COMMUNIS Ulrich.

Pl. XXXIX, Fig. 3a, and Pl. XLI, Fig. 5-5b.

This species is closely related to the preceding, but differs in being more robust in growth, in having well marked maculæ, with subsolid centers, from which the cell apertures radiate out in all directions. The apertures immediate surrounding the maculæ are also slightly larger than the others, while an obscure concentric arrangement prevails. On the whole, the cell apertures are also somewhat larger, and the peristomes thicker.

Position and locality: Cincinnati group.

This form is commonest in the layers exposed in the river bank opposite Cincinnati, O., where *D. vaupeli* is not known to occur. It has a vertical range of about 125 feet, and in the last 25 feet, the two species are found associated.

CREPIPORA Ulrich, 1882.

(Jour. Cin. Soc. Nat. Hist., vol. V, p. 157.)

(For generic diagnosis see page 380.)

This genus differs from *Ceramoporella* Ulrich, mainly, in the nearly complete restriction of the mesopores to the maculæ. These usually form a conspicuous feature of the surface. The lunarium is also better developed and the zoœcia apertures much less oblique than is usual in that genus. *C. impressa* and *C. solida*, however, are closely related to some of the aberrant forms now classified with *Ceramoporella*.

Five representative species are here described, which, combined, furnish a good idea of the limits of the genus. The subramose, hollow branched species, described by me as *Chætetes venustus*,* although differing widely in its habit of growth, is nevertheless closely allied to *C. simulans*, the type of the genus. Beside these, my cabinet contains material of four or five undescribed species, all of them from the Cincinnati group. An Upper Silurian species, closely related to *C. epidermata*, occurs at Gotland. It is known to European palæontologists as *Discopora squamata* (Lonsdale sp.)

CREPIPORA SIMULANS Ulrich.

Pl. XXXIX, Fig. 4-4a, and Pl. XL, Fig. 3-3a.

Zoarium encrusting, sometimes forming crusts of greater or less thickness, at other times irregular masses by the development of successive layers. Thickness of layers varying from one to five mm. Surface exhibiting at intervals of three or four mm. small clusters of mesopores, which are usually abruptly elevated and surrounded by zoœcia with larger orifices than ordinary. Apertures arranged in more or less regular curving series, a somewhat concentric arrangement about the maculæ prevailing; rhomboidal or subpolygonal in outline, 0.22 to 0.4 mm. in diameter, the average being 0.25 mm.; about seven of those in the intermacular spaces in two mm. Lunarium only observable at the surface of the well preserved examples. Zoœcial tubes scarcely prostrate at their origin, then proceeding almost direct to the surface; walls thin throughout. In sections the zoœcia are seen to be angular, sub-rhomboidal and in contact with one another; the lunarium small, with the ends projecting a little into the zoœcial cavity and composed of much lighter tissue than the rest of the wall. Mesopores developed only in the mature portion of the zoarium, restricted to clusters in which they number from ten to forty, thick walled, rather variable in size and shape, oftenest oval. Among them the observer may detect very small acanthopore-like structures. Diaphragms thin, about a tube diameter or more apart.

This fine species is related to *C. venusta* Ulr., but that species is essentially free and grows into irregular hollow branches. The zoœcial walls are also considerably thicker. In *C. impressa* Ulr., the lunarium is much more pronounced, and the maculæ larger and depressed instead of elevated.

Position and locality: Not uncommon near the tops of the hills about Cincinnati, O. I have also collected the species at Madison, Ind., and seen one specimen from Wilmington, Ill.

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*Jour. Cin. Soc. Nat. Hist., vol. 1. p. 93, 1878.

CREPIPORA EPIDERMATA Ulrich.

Pl. XL, Fig. 1-1e.

Zoarium forming a subcircular undulating expansion, attaining a diameter of eight cm. or more; the thickness varies from two to eight mm. Upper surface with slightly elevated large maculæ of mesopores, varying both in size and arrangement; usually about four or five mm. apart. Apertures directed outward from the center of the zoarium, the lunarium being moderately conspicuous, with no striking regularity of arrangement, sub-circular to sub-triangular, 0.4 to 0.6 mm. in diameter; about six in three mm. Zoœcial tubes with walls rather thin throughout, very soon after their origin proceeding almost direct to the surface. Usually a single diaphragm is developed in each tube. Lunarium occupying about one-third of the wall, with a radial structure as shown in fig. 1e, pl. XL. Mesopores abundant, variable in shape and size, scattered about among the zoœcia, but mainly gathered into clusters of fifteen to fifty; very irregular in vertical section, sometimes provided with a few diaphragms.

The form of the zoarium, the structure of the lunarium, and certain peculiarities of the mesopores, suggest affinities with the FISTULIPORIDÆ. Specifically it is widely different from all the other species of the genus excepting *C. squamata* (*Discopora squamata* Lonsdale,) from the Upper Silurian rocks of England and Gotland. The European form differs in several respects, such as having the maculæ smaller and the zoœcia apertures more oblique. The zoarium is also less robust.

Position and locality: Cincinnati group; common at Wilmington, Ill.

CREPIPORA IMPRESSA Ulrich.

Pl. XL, Fig. 2-2a.

This species, which has all the characters of the genus, is chiefly distinguished by having exceptionally conspicuous lunaria, and large sized, but irregularly distributed maculæ, depressed below the general level of the surface. The single specimen seen is an elongated, hollow stem four cm. long by six mm. in average diameter. It evidently grew upon some cylindrical body which has since been destroyed. Cell apertures direct, transversely oval or sub-circular, with the teeth or ends of the scarcely elevated lunarium projecting strongly into the visceral cavity, generally arranged in a somewhat concentric manner about the maculæ. The apertures immediately surrounding the maculæ are a little larger than the rest; about eight of the average size in three mm. A considerable number of mesopores interspersed among the zoœcia in addition to the clusters of sixty to one hundred.

Position and locality: Cincinnati group; Covington, Ky.

CREPIPORA SOLIDA Ulrich.

Pl. XL, fig. 4-4*b*.

Zoarium forming a thin crust attached to foreign bodies (in the type specimens on *Orthoceras*); less than a mm. in thickness. Surface studded with apparently solid small conical monticules about four mm. apart. Apertures rhombic or long oval, frequently very irregular, especially near the monticules, with strongly arching hood, making them appear more oblique when the example is in a good state of preservation, than when somewhat weathered; about six in two mm. Maculæ composed of solid intertwining tissue and mesopores, having a somewhat radial arrangement. A moderate number of mesopores interspersed among the zoœcia. Lunaria very pronounced in tangential sections.

The conical, sub-solid monticules give this species a very characteristic appearance, not possessed by any other known to me.

Position and locality: Cincinnati group; in a small creek south of Covington, Ky.

CREPIPORA HEMISPHÆRICA Ulrich.

Pl. XL, fig. 5-5*b*.

Zoarium hemispheric or discoidal, commonly about four cm. in diameter and two cm. in height; base flattened or concave, concentrically wrinkled. Upper surface even. Apertures direct, rhombic or subpolygonal, with no marked regularity of arrangement, seven or eight in three mm. There are groups of slightly larger cell apertures which are arranged about small and scarcely perceptible maculæ. Walls of zoœcia thin and with a peculiar ragged structure. Lunaria inconspicuous, easily overlooked. Mesopores few, generally only two or three at the center of the clusters. They are without the lunarium and have thicker walls than the zoœcia. Diaphragms thin and somewhat more than their own diameter apart.

The external form, and the extreme paucity of the mesopores, distinguish this species from all the prescribed forms. It is more closely approached by a large massive species that occurs rather abundantly in a layer at the base of the Cincinnati group, which is exposed near Harrodsburg, Ky.

Position and locality: Cincinnati group; not uncommon at Wilmington, Ill.

Anolotichia Ulrich.

(For generic diagnosis see page 381.)

This genus is proposed for the reception of the following species, and another that I have lately described from the Trenton shales of Minnesota as *Crepipora impolita*, (14th Ann. Rep. St. Geol. Minn.). The tubulose structure of the lunarium is regarded as the principal distinctive character. The number of these minute vertical tubes varies with the species, since in the Minnesota form there are usually only three to each lunarium, while in the Illinois species there are from five to seven.

Anolotichia ponderosa Ulrich.

Pl. XLI, fig. 3-3*d*.

Zoarium forming large, irregular, massive branches. Surface smooth. Apertures approximately direct, irregularly sub-circular or oval, eight or nine in three mm. Their arrangement is rather irregular, and there are no clusters of large ones. Lunarial hood inconspicuous, with minute pores in the perfect state. Zoœcial tubes thin-walled throughout, yet considerably stronger near the surface than in the axial region, proceeding from an imaginary axis to the surface with a gradual curve. Diaphragms thin, about two tube diameters apart. Mesopores, variable in shape and of moderate size, are numerously interspersed among the zoœcia. In thin sections the lunaria present a very peculiar feature. Thus, when the tube is cut transversely the lunarial or narrowest side is apparently composed of alternating intervals of light and dark color. When viewed under a high power the light intervals are seen to be of circular form, and with the aid of vertical sections, we learn that they are really of the nature of small vertical tubes. Two of the sides must have been bounded by extremely thin walls, as they are only very rarely preserved, the appearance ordinarily presented in tangential sections being that of a simple perforation in the zoœcial wall. These small tubes, of which there are usually about six in each lunarium, appear to have been crossed by numerous diaphragms, usually about twice their diameter apart.

The massive ramose zoarium, and large zoœcia, suffice to separate this species from all associated Bryozoa.

Position and locality: Cincinnati group; very abundant at Wilmington, Ill.

FISTULIPORA McCoy, 1849.

(Ann. and Mag. Nat. Hist. ser. 2, Vol. III, p. 131.)

(For generic diagnosis see page 382.)

It is only since December, 1885, that we know exactly what form McCoy had before him when he proposed this genus. At the date cited there appeared in the Ann. & Mag. of Nat. Hist. a valuable treatise on the genus *Fistulipora* by Dr. H. A. Nicholson and Mr. A. H. Foord. The authors show that Dr. Nicholson's identification of McCoy's *F. minor** (upon which I had based my estimate of the character of the genus†) was incorrect the new name *F. mucosa* being applied to the species. It further appears that McCoy's *F. minor* is identical with Phillip's

* Palæozoic Tabulate Corals, 1879.

† Am. Pal. Bry. Jour. Cin. Soc. Nat. Hist. Vol. VII, p. 43, 1884.

earlier *Calamopora incrustans*. Founded upon this species, *Fistulipora* exactly occupies the ground that I had proposed to assign to *Lichenalia* of Hall (*loc. cit.*) Unless it can be shown that the original New York specimens, upon which *Lichenalia* was founded, are different from the very abundant Niagara species at Waldron, Ind., that is generally identified with *L. concentrica*, Hall's name must be abandoned. Strictly then, *Fistulipora* includes all the unilaminar forms in which the lunarium ("folds") is a recognizable feature. I am still in doubt what course to pursue in disposing the large group of species (at least fifteen) in which the lunarium is obsolete and the zoœcial apertures circular or oval. *Fistulipora minor* Nicholson (*non* McCoy) seemed to belong to this group‡ and, relying upon the correctness of Dr. Nicholson's identification, I proposed in my Am. Pal. Bry. to restrict *Fistulipora* to species of that type. But, as already mentioned, *F. incrustans*, the type of the genus, has distinct lunaria, and all the characters usually assigded to *Lichenalia*, hence it is clear my proposal cannot be entertained, and that *Fistulipora* as defined by me though possibly congeneric, is not strictly identical with typical *Fistulipora*.

Hall's new genus *Thallostigma** is proposed for Bryozoa with all the characters *Fistulipora* (*Lichenalia*) excepting that the interzoœcial spaces exhibit the cavities of the vesicles at the surface. This feature is not of structural value and, in every case that has come under my observation, it represented either the young condition when the vesicles were forming, or the interior of the vesicles was exposed by attrition.

The range of the genus as no understood is very extensive, a large massive form, not yet described, having lately been discovered in the Galena limestone of Manitoba. Several Cincinnati group species which have been referred to the genus, prove upon examination to belong to the CERAMOPORIDÆ, and, so far as I now am informed, no true *Fistulipora* occurs in these

‡ Nicholson and Foord's figures of the species show faint "folds" in the walls which were deither mentioned nor figured by Dr. Nicholson.

* Trans. Alb. Inst. Vol. X, 1883. (Abstract published in 1881.) In Vol. VI, Pal. N. Y. Prof. Hall abandons this name in favor of *Fistulipora*.

rocks. In the Upper Silurian rocks; however, the genus is represented by at least ten species, in Devonian by from twenty to thirty, in Lower Carboniferous by perhaps an equal number, and terminates its existence in the Coal Measures, with five or six species. The total number of valid species known to me from American rocks alone is not less than seventy, while fourteen species are recorded from European deposits.

Fistulipora communis Ulrich.

Pl. XLVII. fig. 1, 1a. Pl. XLVIII, fig. 1, 1a.

Zoarium explanate, commonly attached to foreign bodies, at other times free and provided with an epitheca, often composed of layers, each a mm. or two in thickness. The surface is raised into low, broad, rounded monticules two or three mm. wide, and their summits three or four mm. apart. Apertures circular with a very thin but distinctlv elevated peristome, generally about 0.16 mm. in diameter, but attaining a diameter of 0.25 mm. near the summits of the monticules; distances apart rather variable, those in the monticules more separated than the others. In the intermediate spaces five or six occur in two mm. When the surface is worn the apertures appear quite small and the interspaces very wide. Zoœcia thin walled, circular or oval, provided with two or three distant diaphragms. Lunarium obsolete. Vesicles thin-walled, generally wide and shallow, about two-thirds as wide as the zoœcia, surrounding them in two or more series and forming large clusters under the monticules. In good tangential sections the vesicle spaces exhibit one or more subcentral minute spots, which probable represent perforations in their covers.

This very abundant species was at first supposed to be the *F. minuta* of Rominger, but from an examination of authentic specimens of that species, it appears that his species is closely allied to *Lioclema occidens* (H. & W. sp.) and not a *Fistulipora* at all. The small zoœcia, their circular form, and the obsolete lunarium, distinguish *F. communis* from the associated species.

Position and locality: Hamilton group. Buffalo, Iowa, and Rock Island, Ill.

FISTULIPORA MONTICULATA Ulrich.

Pl. XLVII, fig. 3–3b. Pl. XLVIII, fig. 2, 2a.

Zoarium consisting of more or less compressed hollow branches one to three cm. in width and two and one-half to five mm. in thickness; actual thickness of zoarium less than two mm. Surface generally with broad rounded monticules of moderate elevation, four or five mm. apart and arranged in diagonal rows. Monticules composed chiefly of vesicles and hence have a subsolid appearance on the surface. Apertures with thick rounded peristomes, more elevated on one side; somewhat irregular in shape, commonly oval, 0.2 to 0.3 mm. in their greatest diameter, about half their diameter apart. Zoœcial walls only moderately thin sometimes ring-like, the lunarium distinct, but with the ends scarcely projecting into the zoœcial cavity. Vesicles sub-angular, about two-thirds as large as the zoœcia, seldom in more than a single row between the zoœcia, shallow, often arranged in quite regular vertical series. Diaphragms developed occasionally in the zoœcial tubes. Vertical sections indicate that upon the floor of each vesicle there was a calcareous deposit.

Typical examples like that represented by fig. 3, are readily distinguished from other species of the genus. When without monticules the species bears some resemblance to *F. utricula* Rominger, but the absence of spines, which are a characteristic feature of the surface of Rominger's species is sufficient to show their distinctness.

Position and locality: Hamilton group, Buffalo, Iowa.

FISTULIPORA ASTRICA Ulrich.

Pl. XLVII, fig. 5–5b. Pl. XLVIII, fig. 3.

Zoarium consisting of large, hollow, compressed branches, or laminar expansions, several cm. wide, one and one-half to three mm. thick. Surface marked with large, showy, depressed, star-shaped maculæ, at somewhat variable distances apart, averaging six mm. measuring from center to center, forming rows of greater or less regularity. Apertures sub-triangular or, more commonly, pyriform, bidenticulate, with the lunarium prominent, about six of the intermacular apertures in two mm. Zoœcia with thin walls and diaphragms about two diameters apart. Vesicles rather large but irregular in shape and size, rarely in more than a single series between the zoœcia.

This fine species is distinguished from all Devonian species of the genus by the larger and decidedly stellate maculæ. These lend the species considerable resemblance to *F. asteria* Prout, from the Keokuk group. In other respects, however they are quite distinct.

Position and locality: Hamilton group, Buffalo, Iowa.

FISTULIPORA COLLINA Ulrich.

Pl. XLVII, Fig. 6-6b, and Pl. XLVIII, Fig. 5-5a.

Zoarium a circular expansion, five or more cm. in width and one to three mm. in thickness; a wrinkled epitheca upon the lower side. Surface with solid, more or less prominent, elongated maculæ or monticules, set in cross rows, their summits about four mm. apart. Zoœcial apertures arranged in somewhat concentric rows about the monticules, diminishing very slightly in size as they recede from the monticules; sub-oval or circular in shape, averaging 0.22 mm. but varying from 0.17 to 0.27 in diameter, about one-half their diameter apart, about eight in three mm. Apertures, so far as observed, without a distinct peristome, the lunarium too being generally obsolete, but occasionally the apertures appear somewhat oblique on account of a slight prominence of the posterior margin. In thin sections the zoœcial tubes are seen to contain a small number of diaphragms, their walls being thin, the lunarium unrecognizable, the vesicles comparatively small, of nearly uniform size, but varying from one-third to two-thirds the size of the zoœcia, moderately shallow, angular, usually in only a single series between the zoœzia, though a double row is commonly present between those which open upon the slopes of the monticules. All the walls have a minutely granular or intermittent appearance.

In some respects this species resembles *F. communis* and *F. monticulata*, two common species at Buffalo, Iowa, which are described in this work as new. The absence of a complete peristome and smaller vesicles separate *F. collina* from both, while the larger zoœcia help in distinguishing it from the former, and the different habit of growth from the latter.

Position and locality: Hamilton group. Comparatively rare at Buffalo, Iowa.

Fistulipora foordi Ulrich.

Pl. XLVII, Fig. 7-7a, and Pl. XLVIII, Fig. 4-4a.

Zoarium a broad expansion; when complete, probably eight to ten cm. wide; the only example seen is two and one-half mm. thick at the edges, and five mm. in the thickest part. Under surface with an epitheca marked by rather faint irregularly concentric wrinkles. Large solid maculæ, nearly on a level with the surface, occur at intervals of six to eight mm., measuring from center to center. Apertures immediately surrounding the maculæ, larger and more prominent than the others, decreasing gradually in size toward the middle of the inter-macular spaces, from 0.2 to 0.4 mm. in diameter, arranged in regular intersecting series, sub-triangular or pyriform in shape. Lunarium very prominent, usually giving the apertures a decidedly oblique appearance. When the apertures are closed by opercular covers, the zoarial surface seems studded with triangular points, a little more than the diameter of their base apart; about ten in 5 mm. Interspaces in general slightly concave, but exhibiting irregular, faintly convex spaces, which are most distinct on the surface of the maculæ. Zoœcial tubes a little oblique to the surface, with diaphragms somewhat more than their own diameter apart. The two ends of the lunarium project strongly into the broadly pyriform zoœcia. Vesicles large, angular, irregular in shape, forming but a single series between the zoœcia, less shallow (in vertical section) than usual; the maculæ are entirely made up of them. Tangential sections show that the interspaces are really of less width than the zoœcia.

The present species is, perhaps, nearer related to *F. astrica* Ulr., also from the Hamilton group, than to any other species known to me. The points of dissimilarity between them are, however, quite marked, and it is scarcely possible that they will be confounded.

Position and locality: Hamilton group, Rockford, Iowa.

Fistulipora spinulifera Rominger.

Pl. XLVI, Fig. 3-3d.

Fistulipora spinulifera Rominger, 1866. Proc. Acad. Nat. Sci. Phila., p. 121.

Zoarium ramose, branches one to three cm. in diameter. Surface monticulose; the small, prominent, conical, and sub-solid monticules about three mm. apart, and arranged in rows of considerable regularity. Monticules composed of vesicular tissue and, like the interzoœcial spaces, minutely spinous when in a good state of preservation. Apertures sub-oval, about 0.20 mm. in their greatest width, and between six and seven in two mm. Lunarium but little elevated, the ends sometimes prominent and projecting slightly into the zoœcial cavity. Zoœcial tubes thin walled, proceeding in a gradual curve to the surface upon which they open almost perpendicularly. Diaphragms rather irregular in position and distribution, none in the central part, few in the outer portion of the axial region, numerous in the cortical region. Vesicles irregular, usually small, angular, very large in the axial region, becoming gradually much shallower toward the surface, surrounding the zoœcia in one or two series. In tangential sections the lunarium shows but faintly. These sections also show a large number of small spots, that resemble thin-walled acanthopores. They do not appear to form continuous tubuli.

This form closely resembles monticulated specimens of an associated species of *Monotrypella*, from which it should be discriminated. An examination with the hand lens readily does this. The ramose habit of growth, solid branches, and comparatively thin granulose interspaces, distinguish it from other species of the genus.

Position and locality: Hamilton group, Alpena, Mich.

Fistulipora (? Dichotrypa) corrugata Ulrich.

Pl. XLVII, Fig. 8-8a, and Pl. XLVIII, Fig. 6-6b.

Zoarium an irregular undulating or somewhat distorted expansion, one mm. or there about in thickness. Under surface with a concentrically wrinkled epitheca, the wrinkles strong, subequal, and closely approximated. Sharply defined, small solid maculæ, of stellate form, dot the celluliferous surface and are but little if any raised above it. Measuring from center to center they are about 2.5 mm. apart. The maculæ are surrounded by comparatively large apertures, facing outward; having the hood or lunarium very prominent. Apertures oblique, sub-triangular or pyriform, bidenticulate, hooded, about 0.15 mm. in diameter, rather closely approximated, an average of twelve or thirteen in three mm. Zoœcia at first oblique, then direct. The primitive cells, as shown by deep tangential sections, are of elongate semi-cordate form, and arranged between longitudinal lines. Here they sometimes show a feature that reminds me of a superior hemiseptum. Diaphragms apparently wanting. Vesicles varying in shape, angular, approaching in size to the zoœcia. In the upper part of the zoarium the vesicles are filled up or replaced by solid calcareous matter, exhibiting in good sections a large number of minute dark spots.

The distinctive features of this neat and well marked species are the small and closely approximated zoœcia, the strong and regular wrinkles of the epitheca, and the general resemblance of the zoœcial structure to that of the CYSTODICTYONIDÆ. Should it prove that the form is *bifoliate* then it would have to be regarded as an unqualified species of *Dichotrypa*. In any event I am strongly inclined to place it there.

Position and locality: Hamilton group, Thunder Bay, Mich.

FISTULIPORA STELLIFERA Rominger.

Pl. XLVII. fig. 2, 2*a*.

Fistulipora stellifera Rominger. 1866. Proc. Acad. Nat. Sci. Phila. p. 120.

Zoarium sometimes unilaminar, more commonly rising into bifoliate expansions, from one to three mm. thick. Surface nearly even, but sometimes the maculæ are slightly elevated. Maculæ of stellate appearance, about four mm. from center to center, the central portion and rays concave, smooth or finely granular, appearing solid at the surface. Apertures oval or circular, with prominent peristome, one side (lunarium) often more elevated than the other. In perfect examples, the rim bears from six to eight small blunt spines. The arrangement of the zoœcia apertures is quite regular, radial series being the most marked around the maculæ, where they are also slightly larger and separated by wider interspaces than in the intermacular spaces. Here they are rather closely approximated, about six in two mm., with an average diameter of 0.18 mm.

In sections the lunarium is illy defined, the zoœcia appearing as regularly oval or circular. The interspaces are occupied by a single series of rather large, angular vesicles, but in the immediate vicinity of the maculæ they often form double series. In vertical sections the zoœcial tubes bend abruptly outward from the irregularly flexuous median laminæ, and, a short distance above the bend are usually crossed by a diaphragm. The vesicles decrease in height toward the surface, and near it are largely filled by a secondary deposit of sclerenchyma.

The bifoliate zoarium suggests comparison with *Meekopora*, Ulr., but I cannot find that the species approaches that genus in any other respect. In its zoœcial features it agrees closely with the section of *Fistulipora* typified by *F. communis* Ulr.

The specimen here figured is identical with a number of examples collected at Rominger's original locality by Mr. J. M. Nickles. It also agrees quite closely with an authentic example of the species, the principal difference noted being a slightly greater elevation of the lunarium in the latter.

Position and locality: Hamilton group, near Alpena, Mich., where it was collected by Rev. W. H. Barris, who kindly presented it to the author.

MEEKOPORA Ulrich.

(For generic diagnosis see page 383.)

The two principal peculiarities of this genus, *i. e.*, the bifoliate zoarium and the uniform direction of the zoœcia apertures toward the distal end of the zoarium, render it more than ordinarily easy of determination. In their general form and construction the zoaria of *Meekopora* resemble those of *Dichotrypa*, and the careless observer will probably confound them. A little care, however, in comparing species of the two genera will soon bring to light several important differences, the genus under consideration being an unequivocal member of the FISTULIPORIDÆ, while *Dichotrypa* is an equally true division of the CYSTODICTYONIDÆ. A comparison of vertical sections brings to light some of the most striking differences (see Pl. LXXVI, fig. 9*b*, and Pl. LXXVII, fig. 7*b*). Thus the zoœcial tubes in *Dichotrypa* are recumbent on the median lamina, then bending outward abruptly proceed direct to the surface. A more or less developed superior hemiseptum is usually recognizable, but diaphragms are absent. On the other hand in *Meekopora* the tubes are gently curved throughout their length from the median laminæ to their apertures without becoming direct and, while hemisepta are wanting, numerous diaphragms are present. Other important differences might be pointed out, but as they will be obvious enough to the student, the above are deemed sufficient for the present.

Four species are now referred to the genus, one of them provisionally. Beside these my cabinet contains three more. All the species now positively known to have the structure of the genus are from Lower Carboniferous deposits.

MEEKOPORA EXIMIA Ulrich.

Pl. LXXVII, fig. 6-6*d*.

Zoarium a bifoliate, somewhat undulating, palmate expansion, several cm. in width and two to five mm. in thickness. Surface presenting large, slightly elevated, oval, smooth spots or maculæ, arranged in somewhat regular diagonal rows, five or six mm. apart. The apertures immediately surrounding the maculæ a little larger than the others. Apertures in rather regular oblique rows, all facing up toward the distal part of the zoarium, sub-triangular or semicircular in outline, with prominent overarching lunarial hoods; six or seven apertures in three mm., each with a diameter of about 0.21. Oœcia few, taking the place of one of the zoœcia and consisting of a cystoid elevation of the surface, with a small perforation at the apex. Zoœcial tubes thin walled, extending with a gradual curve to the surface, without, however, becoming direct. Lunarium usually obsolete in tangential sections, but sometimes the ends project slightly into the visceral cavity. The axial plane consists of two very thin closely adhering flexuous epithecal membranes. Vesicles of irregular shape, much the largest near the axial plane, often exhibiting an obscure concentric arrangement around the zoœcia. As they approach the surface the floor of the vesicles (the top of the underlying one) is covered with a deposit of light colored sclerenchyma, which appears to be traversed by minute vertical canals. Near the surface this perforated deposit entirely fills the vesicles. It is of darker color in the immediate vicinity of the zoœcia. In tangential sections showing the characters just beneath the surface the zoœcia are circular, the vesicles and lunaria unrecognizable, at a deeper level the lunarium is fairly well shown, and the form of the numerous vesicles, though they are still partially filled with the deposit. is readily determinable. At the median plane the zoœcia are arranged between longitudinal lines. These sections also show that the interspaces gradually increase in width, while the zoœcia diameter decreases with growth. Diaphragms fairly numerous, flat or slightly concave, a tube diameter or less distant from each other.

This fine species need not be confounded with any bryozoan known to me from either the St. Louis or the Chester horizon.

Position and locality: Near the dividing line between the St. Louis and Chester group, Monroe Co., Ill. The species may be found both above and below the line.

Meekopora approximata Ulrich.

Pl. LXXVII, fig. 5.

Zoarium bifoliate, growing into irregularly undulating thin expansions, from one to one and a half mm. thick. Surface smooth, with small solid maculæ, their centers four to five mm. apart. Apertures closely approximated, oblique, sub-circular or subtriagular in outline, 0.20 to 0.30 mm. in diameter, arranged in more or less regular diagonally intersecting rows, seven in three mm. measuring along the rows; interspaces thin, the lower margin of the aperture elevated into a prominent hood. Median laminæ forming a rugosely wrinkled plane from which the zoœcial tubes proceed with a gradual curve to the surface which they reach obliquely. Diaphragms usually flat, most abundant in the deeper portion of the zoarium, where also they are often recurved. Lunaria quite angular in tangential sections, but their ends rarely if ever project into the zoœcial cavity. The vesicles resting upon the median laminæ are elongated in the direction of growth, those resting upon them are smaller, angular, comparatively few, and often failing to completely isolate the zoœcia.

This species is to be compared with *M. eximia*, but the thinner zoarium, much more closely arranged zoœcia and smaller maculæ distinguish the two species without much trouble. Thin sections furnish additional differences. An undescribed associated species is not so readily separated, though differing in several important particulars. Its zoarium is two or three times as thick, the zoœcia separated by somewhat wider interspaces, and all the diaphragms strongly recurved.

Position and locality: Chester group. Chester, Ill. Sloan's Valley, Ky.

MEEKOPORA CLAUSA Ulrich.

Pl. LXXVI, fig. 6 and Pl. LXXVII, fig. 7—7b.

Fistulipora? clausa Ulrich, 1884. Jour. Cin. Soc. Nat. Hist. Vol. 7, p. 47. Pl. 3, fig. 4, 4b.

This species of which a full description was given in the reference above cited, was there referred to *Fistulipora* with an (?) added. The weighty points in which it differs from *Fistulipora* then pointed to a generic separation which I was unwilling to make without first finding similar species. This has been done and the genus *Meekopora* established for their reception. *M. clausa* is related to *M. eximia* the type of the genus, but differs too conspicuously in its habit of growth and other characters to admit of confusing them.

Position and locality: Chester group. The types are from Sloan's Valley and Grayson Co., Ky., but I have seen specimens from Chester, Ill.

MEEKOPORA? APERTA Ulrich.

Pl. LXXVI, fig. 1, 1a.

Zoarium consisting of small compressed branches, several cm. in height, about three to five mm. in width by one mm. in greatest thickness; cross section of branches lenticular; margin acute, smooth or obscurely granular. Apertures subcircular or oval, with a beveled margin, slightly flaring, from 0.20 to 0.25 mm. in diameter, arranged in diagonal curved rows, about four in 2 mm. Interspaces slightly concave, rising around the apertures to form a kind of peristome, which is more elevated below than above, causing the apertures to appear slightly oblique and directed toward the distal portion of the zoarium. Lunarium indistinct. Axial membranes very thin and somewhat flexuous. Zoœcial tubes for a short distance prostrate, then curving abruptly they proceed to the surface at nearly a right angle. Diaphragms appear to be wanting. Vesicles angular with an obscure longitudinal arrangement, those along the median laminæ very large, diminishing in size and increasing in numbers with age. Near the surface they are replaced by or filled with calcareous tissue.

The general appearance of this species is so much like that of species of *Cystodictya* that I was at first inclined to refer it to that genus. Upon a closer examination, however, I found that the principal zoœcial characters of the CYSTODICTYONIDÆ were absent, and that in these features the species presented a marked resemblance to *Meekopora*. Some care is required in distinguishing *M. aperta* from certain forms of *Cystodictya pustulosa* Ulrich, and it will not surprise me should future investigations prove these two species more closely related than is shown by the material now at hand.

Position and locality: Keokuk group. Rare at King's Mountain, Ky.

STROTOPORA Ulrich.

(For generic diagnosis see page 383.)

This genus is proposed to include a small group of Fistuliporoid species having a peculiar feature in common, which in most cases is sufficiently obvious to render their separation from other genera of the family a comparatively easy task. The peculiarity referred to, in the ordinary state of preservation, presents itself in the shape of large abruptly spreading cells, having at the bottom an aperture of the average zoœcia size, and a thin irregular elevated margin. When perfect they appear as laterally perforated, prominent, round and smooth tubercles, about 0.5 mm. in diameter. That they represent oœcia will scarcely admit of doubt. The following three species are all that are positively known to have this character, but another form, of which my material is not good, most probably also belongs to the genus.

Strotopora perminuta Ulrich.

Pl. XLVII, fig. 4—4b.

Zoarium having the form of small, irregular, hollow branches, with a rugosely wrinkled epitheca on the inside; thickness of zoarium 0.5 mm. or a little more. Surface with subsolid, slightly elevated, conical monticules, about two mm. apart from center to center. Slopes of monticules occupied by zoœcia facing outward from the center, so as to form radiating series. Apertures suboval, but generally a little irregular in shape, 0.10 to 0.12 mm. in diameter, and eleven or twelve in three mm. Lunarium very prominent and overarching. Interspaces once and a half to twice the width of the apertures. Oœcia comparatively small, about 0.4 mm. in diameter, with an eccentric opening at the bottom; when perfect with a dome shaped covering in which there is a lateral opening. They vary somewhat in number on different fragments, being numerous on some and few on others.

The minuteness of the zoœcia, the delicate zoarium, and the dome-shaped oœcia, distinguish this species from all Fistuliporoid Bryozoa known to me from Devonian rocks. This species is smaller in every respect than the Keokuk species next described.

Position and locality: Middle Devonian. Falls of the Ohio.

Strotopora foveolata Ulrich.

Pl. LXXVII, Fig. 9-9a.

Zoarium having the form of solid compressed branches; four or more cm. high, two or three cm. wide and four to eight mm. thick. Surface with low, broad, rounded, generally transversely elongated monticules. Inter-monticular spaces less than the width of the monticules. Apertures irregularly arranged, the interspaces being of variable width, those upon the monticules more separated than the others; varying also in size and shape, some being circular, others oval or sub-triangular, 0.29 to 0.30 mm. in diameter, and seven or eight in three mm. Lunarium or hood moderately developed, occupying one side of the apertures. Oœcia numerous, but without regularity of arrangement, sometimes a number occur in close proximity to each other; bowl-shaped, about three times as wide as the zoœcia, with prominent margins, circular or irregularly indented by the encroaching zoœcia; in their perfect state, as shown by well preserved specimens, over-arched by a dome-shaped covering, having a small round or crescentic opening upon one side. Center of branch, in the specimens at hand, crushed out of shape. Zoœcia rectangular to surface in the latter part of their course; provided with fairly numerous, thick, flat, or sometimes recurved diaphragms. Vesicles surrounding the zoœcia in a single or double series, uniform in depth, angular, variable in size and shape, replaced near the surface by calcareous tissue, which is perforated by numerous, small, longitudinal, irregularly arranged tubuli, establishing communication between the surface and vesicles. Lunarium composed of lighter colored tissue, occupying about one-third of the circumferance of the zoœcium.

In the form and general aspect of the zoarium this species resembles *Fistulipora compressa* Rominger, a common species of the Keokuk limestone. Indifferently preserved examples might be confounded, but when in a good, or even in the ordinary state of preservation, the oœcia of the one serve excellently in discriminating between them.

Position and locality; Keokuk group, Bentonsport, Iowa, and Warsaw, Ill.

STROTOPORA DERMATA Ulrich.

Pl. LXXVII, Fig. 8-8a.

This species like *S. foveolata*, the type of the genus, consists of compressed branches, but they are much less robust in every respect, the thickness being seldom more than two mm. The branches too seem always to have been hollow, with an epithecal lining on the inner side. The surface is more even, the cell apertures are smaller, more rounded, the lunarium not so well marked, the interspaces comparatively wider and slightly elevated, so that they appear to slope down into the zoœcial apertures; of these about eight occur in three mm. The oœcia are rather smaller, and the zoœcial openings in the bottom, eccentric in position. The oœcia, though also irregularly distributed, are less so than in *S. foveolata*. An arrangement in transverse series is common. Interspaces minutely granular or pitted.

Position and locality: Keokuk group, Keokuk, Iowa, and Warsaw, Ill. The specimens from Warsaw are a little more robust than those from Keokuk. Not rare.

BUSKOPORA Ulrich, 1886.

(Contr. Am. Pal. vol. 1, No. 1, p. 22.)

(For generic diagnosis see page 383.)

BUSKOPORA LUNATA Rominger.

Pl. XLVII, Fig. 7-7d.

Fistulipora lunata Rominger. Proc. Acad. Nat. Sci. Phila., 1866.
Lichenalia lunata Hall. Trans. Albany Institute, vol. X, abstract, p. 10, 1881.
Buskopora dentata Ulrich, 1886. Contri. Am. Pal., vol. I. p. 22, Pl. II, fig. 5-5a.
Lichenalia lunata Hall. Rept. St. Geol. for 1885. Expl. to pl. 31, fig. 1-9, 1887.
Lichenalia lunata Hall, Pal. N. Y., vol. VI, p. 77, Pl. 31, figs. 1-9, 1887.

A fine example lately obtained enables me to add some information about this species. The example is evidently more mature, its greatest thickness being about 4 mm., and shows the fully developed characters at one point. Here the zoœcia apertures are much smaller than usual and the interspaces proportionally wider. Upon close examination I find that this peculiar appearance is due to a large portion of the original aperature being covered by a thin membrane. The present orifice occupies the space between the lunarium and the opposite wall and is of oval or subcircular shape. The specimens being silicified and entirely free from the matrix, it shows, where fractured, the character of the interior. Fig. 7d represents a portion of a vertical fracture and shows several zoœcial tubes with the internal ridge and lunarium. Also the vesicles of the interspaces. Diaphragms are few or absent in this example. Hall says septa (diaphragms) are "frequent."

Position and locality: Middle Devonian, (Upper Helderberg?), Falls of the Ohio.

BOTRYLLOPORA Nicholson, 1874.

(Can. Jour., vol. XIV, No 2.

(For generic diagnosis see page 384.)

BOTRYLLOPORA SOCIALIS Nicholson.

Pl. XLIII, Fig. 9-9b.

Botryllopora socialis Nich., 1874. Geol. Mag. n. s., vol. I, p. 160, Pl. IX, fig. 16.
Botryllopora socialis Nich., 1874. Pal. Ont.. p. 96, fig. 32.
Botryllopora socialis Hall, 1884. Rept. State Geol. for 1883, p. 61.

Zoarium rarely solitary, generally consisting of a greater or less aggregation of approximate or confluent disc-like colonies, attached by their lower surface to foreign bodies; rugose corals and Brachiopods seeming to be the most favored. Sometimes specimens are found that are free, with a strongly wrinkled epitheca below. These again may consist of several successions of colonies growing one upon the other. Ordinarily, however, there is but one layer of about one mm. in thickness. Diameter of discs varying from two to four mm. Upper surface of disc convex with a central cup-shaped or flattened depression, from which radiate a number of depressed linear spaces, all of about the same width, commonly bifurcating about half way out. Between the depressed spaces are ridges that extend nearly to the margin of the disk; about half way between the center and the margin their number is usually doubled by the interpolation of shorter ridges. Total number of ridges varying from fifteen to twenty-five. Each ridge is occupied by two series of zoœcia, having rather thick adjoining walls, there being no interspaces between them. Zoœcia apertures circular or oval, less than 0.10 mm. in diameter, about eight in one mm., (the length of the long ridges) with horizontal or slightly concave diaphragms, about three tube diameters apart. Central and radiating depressions occupied by angular sub-spherical or flattened vesicles; about two or three times the diameter of the zoœcia. The space between the disks is taked up by much larger irregular vesicles, being several times as wide as those at the center of the disks. These may represent oœcia.

Specimens from different localities vary a great deal in the size of the disks and number of rays. Possibly several species have been thrown together, but without more material than is now before me, it would be unwise to establish more species. In the specimen figured the disks are larger than in any other seen by me.

Position and locality: Hamilton group, Eighteen Mile Creek, N. Y.; Arkona, Canada; Falls of the Ohio; Thunder Bay, Mich. Probably also at Andalusia, Ill.

CYSTODICTYA Ulrich, 1882.

(Jour. Cin. Soc. Nat. Hist. Vol. V, p. 152.)

(For generic diagnosis see page 385.)

This is one of the most important of the Palæozoic genera of Bryozoa, being abundantly represented by both species and individuals, in the upper divisions of the age. No species are as yet known from rocks of earlier date than Devonian, but in the Upper Helderberg and Hamilton deposits the genus makes its advent with a comparatively strong representation, no less than twenty species having already been described that are referable to the genus. Of these seventeen have lately been published by Prof. Hall as species of *Stictopora*. Most of them he illustrates, while the descriptions of the others are sufficiently full to enable me to determine their generic relations. The following clearly belong to *Cystodictya* and *not* to *Stictopora*.*

* I find a foot note on p. 10 of a number of plates and explanations which are published by Prof Hall in advance of his report as State Geologist for 1886. This note reads as follows: "In relation to the genus *Cystodictya*, I may remark that every species of *Stictopora* known to me possesses the characters on which the genus *Cystodictya* has been founded." In answer to this decretory note, I wish to say, that Prof. Hall has either entirely forgotten that his genus *Stictopora* was founded upon Lower Silurian species of very different structure from *Cystodictya*, or he has failed to appreciate the really essential characters of the typical species of his genus. He describes the genus with six species in the Pal. of New York, Vol. 1, published in 1847. On page 16 we find *Stictopora fenestrata*, page 17 *S. glomerata*, p. 50 *S. labyrinthica*, p. 51 *S. ramosa*, p. 74 the generic description and *S.*(?) *acuta*, and on the page following *S. elegantula*. Now

Stictopora crescens, invertis, linearis, ovatipora, perarcta; rigida, semistriata, and *vermicula*, from the Upper Helderberg group; and *S. crenulata, incisurata, limata, ovata, recta-linea, sinuosa, subrigida, trilineata*, and *tumulosa*, from the Hamilton group. Regarding these Devonian species, I have to say at present only that in my opinion Prof. Hall has drawn the specific lines unjustifiably close, and that in some cases at any rate, he has proposed two names where one would have sufficed. Of other Devonian species, having the structure of *Cystodictya, S. gilberti* Meek, *S. meeki* Nicholson, and *S. sulcata* Winchell should be mentioned. In the Kinderhook and Burlington beds we meet with a small undescribed species having pustulose apertures arranged longitudinally between low and broad ridges. In the Keokuk limestone *C. lineata* Ulr., is common, while *C. pustulosa, C. americana*, and *C. nitida*, three new species, are more rare. *C. ocellata* is from a bed in Kentucky, doubtfully referred to the Keokuk group. In the St. Louis limestone we find in great abundance a variety of *C. lineata*, which might be known as *sancti-ludovici;* also a wide form that I will provisionally designate as var. *major*. In the Chester group the genus is represented by one or two undescribed species, and in the Coal Measures we find *C. carbonaria* Meek. The Waverly deposits of Ohio also furnish several species.

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whichever of these five species *S.*(?) *acuta* being unavailable), we may select for the type of the genus, we never approach the ground occupied by *Cystodictya*. *Stictopora* as now employed by me is based upon *S. fenestrata*. This species is congeneric with the forms which I formerly proposed to call *Rhinidictya*, and is one of a number of distinctively Lower Silurian Bryozoa, differing from *Eurydictya* of the present work almost solely in the form of the zoarium, which, instead of broad indefinite expansions, forms slender, parallel-sided bifurcating stipes. The student will do well to compare figures on plate XXX with those of CYSTODICTYONIDÆ on plates 76, 77 and 78. The *S. fenestrata* seems to me to be the most available of the six species originally referred to the genus to stand as the type. *S. glomerata, S. ramosa* and *S. labyrinthica* are too indefinite to have furnished the generic characters, while *S.*(?) *acuta*, although the first to follow the generic description, cannot be utilized because Hall questioned his reference of the species to the genus. *S. elegantula* is the only other species having any claim to the distinction. This species is one of a small but little understood group of species, related to *Stictotrypa* of this work, that most probably should be regarded as generically distinct from the widely distributed group typified by *S. fenestruta* and *S. nicholsoni*, Ulr. In case *S. elegantula* is made the type of the genus, then *Rhinidictya* will stand and *Stictopora* have only two or possibly three representatives. In no case, however, can *Stictopora* be made to include *Cystodictya*.

CYSTODICTYA HAMILTONENSIS Ulrich.

Pl. XLII, fig. 4. and Pl. XLIII, fig. 1.

Zoarium a bifurcating stipe, from 2.5 to 3 mm. in width between the bifurcations, and 0.5 mm. in greatest thickness. Bifurcations frequent, commonly at intervals of about 8 or 9 mm. After bifurcation the two divisions bend a little toward each other. Non-poriferous margin narrow. Cell apertures in parallel longitudinal rows between strong elevated ridges; eight or ten rows just before bifurcation, half going into each division, soon after bifurcation the number of rows reaches by interpolation the normal number seven or eight. Those in adjoining rows alternate with each other, causing an arrangement in intersecting series extending diagonally across the branch. Apertures almost circular or oval, about 0.2 mm. in diameter and six in three mm. measuring lengthwise, those in the marginal rows a little larger than the central ones, with a slightly elevated peristome, a little stronger at the outer side, causing the apertures to appear a little oblique. Lunarium strong only in old examples, usually quite inconspicuous. End spaces equal to about one and a half times the diameter of the cell apertures. Internal structure in accord with generic requirements.

This seems to be a characteristic species of the western exposures of the Hamilton group, if not also of the eastern. It is closely allied to *C. sulcata* (*Stictopora sulcata* Winchell) but differs in the disposition of its parts.

Position and locality: Hamilton group. Buffalo, Iowa and Rock Island, Ill. The same or a very similar form occurs at Eighteen Mile creek in N. Y., and near Milwaukee, Wis., on the lake shore.

CYSTODICTYA NITIDA Ulrich.

Pl. LXXVI, fig. 4—4c.

Zoarium a narrow stipe, about 1.5 to 2 mm. in width, branching dichotomously at intervals of from 8 to 12 mm. Non-poriferous margin very narrow. Apertures in linear series, between scarcely elevated ridges, five to eight of these series upon each face of the zoarium. In the matured perfect state (fig. 4b) the apertures are circular, small, less than 0.1 mm. in diameter, raised above the ridges with prominent projecting peristome. Apertures also arranged in rather irregular diagonally intersecting series across the branch. Summits of the ridges with delicate flexuous lines, the whole of the remaing interspaces finely granulose. In the less mature state (fig. 4c) the apertures are much larger and bounded on two sides by crescentic margins, the outer one (lunarial) promptly elevated, directed slightly toward the center of the stipe and curved to a shorter radius than the opposite. Measured lengthwise six aperturs occur in three mm. obliquely about three in one mm.

This species is much smaller than the *C. lineata* Ulr. It is more closely related to *C. americana* Ulr., which see for comparisons.

Position and locality: Keokuk group. Bentonsport, Iowa.

CYSTODICTYA AMERICANA Ulrich.

Pl. LXXVI, fig. 5, 5a.

Zoarium a long narrow stipe, not observed to branch, about 1.5 mm. in width. Transverse section of branches sub-acutely elliptical, with the two sides more convex than usual. Each side with four or five linear series of apertures, arranged between prominent rounded ridges at the bottom of moderately deep sulci, 5 or 5½ in three mm. Apertures much elevated, small, circular, and about 0.08 mm in diameter in the perfect mature stage; in the ordinary condition much larger, subelliptical, 0.18 mm. in length by 0.13 mm. in width, and with the margin most elevated on the outer side. The cells are also quite regularly arranged in diagonally intersecting series. End spaces from two to four times as long as the diameter of the cell apertures.

This species I formerly considered identical with *C. parallela* Phillips (species) from the Carboniferous shales of Great Britain. Comparisons lately made have shown that the English species has both external and internal peculiarities not possessed by its American representative. It is closely related to *C. nitida* Ulr., but that species has the stipe frequently bifurcated, the zoœcia a little more numerous, and their arrangement in diagonal lines less regular. The longitudinal ridges are stronger, the rows of cells generally less, and the surface more convex in *C. americana*.

Position and locality: Keokuk group; King's Mountain Tunnel, Ky., and Bentonsport, Iowa.

CYSTODICTYA PUSTULOSA Ulrich.

Pl. LXXVI, fig. 2, 2a.

This species differs from *C. lineata* ("Am. Pal. Bry." Jour. Cin. Soc. Nat. Hist. Vol. VII, p. 37, Pl. II, fig. 4, 4c) mainly in the fact that the lines which form so conspicuous a feature on *C. lineata* are obsolete or almost wanting, and that the apertures occupy the summits of prominent papillæ, imparting to the surface a strongly pustulose appearance, quite different from what we find in *C. lineata*. A tangential section dividing the zoœcia just above their decumbent portion shows a very peculiar feature, which I am not yet able to explain. Namely, the zoœcial cavity is here divided longitudinally by a line which commencing at the posterior side of the subcircular wall, extends about three-fourths of the diameter to the opposite side. A similar but shorter line has also been observed in a section of *C. lineata*. These sections also show that the zoœcial cavity is larger in *C. pustulosa* than in *C. lineata*.

Position and locality: Keokuk group; King's Mt. Tunnel, Ky.; Keokuk, Iowa; Warsaw and Nauvoo, Ill.

CYSTODICTYA LINEATA var. MAJOR Ulrich.

Pl. LXXVI, fig. 3.

Comparison of sections of this form with those of typical specimens of *C. lineata* has not developed any appreciable difference in internal structure. Externally this variety is more robust and has three or four more rows of cells than the typical form. All the examples seen are badly preserved. Better material may show differences which are not now obvious.

Position and locality: The specimens are attached to the surface of a slab of rock labelled only "Keokuk limestone." This is probably an error as the character of the rock is decidedly like that of the St. Louis limestone at Alton, Ill.

COSCINIUM Keyserling, 1846.

(Reise in das Petschora Land, p. 191.)

(For generic diagnosis see page 385.)

So far as I am aware the minute characters of the type of this genus have never been made public, so that there is yet a possibility of error when we refer species here. The probabilities, however, are decidedly against *C. cyclops* Keys., being generically distinct from such species as *C. cribriforme* Prout, and *C. latum*, of the present work. These two species belong to a small group that is first met with in the Upper Helderberg, and extends up into the Coal Measures. The form of the zoarium is precisely like that of *Clathropora* Hall, and authors have usually regarded that genus as synonymous with *Coscinium*. This is an error if my understanding of *C. cyclops* is correct, since Hall's genus is closely related to *Ptilodictya* Lonsdale, while *Coscinium*, as defined by me, is an unquestionable member of the CYSTODICTYONIDÆ. In 1859, Prout identified a species from the Falls of the Ohio with the *C. cyclops*, and at the same time described a new species from the same locality as *C. cribriforme*. In my "American Palæozoic Bryozoa," I also described and figured a species as *C. cyclops*. During the progress of this work I have made it a duty to reconsider every previously determined point. In this case the result was more than usually gratifying, since I can now rectify several errors. I learn that the *C. cyclops* of Prout, is the *Clathropora intertexta* Nich., (a true species of that genus) and not the same as Keyserling's species; that my *C. cyclops* and Hall's *Clathropora carinata* (later *Coscinotrypa carinata*) are the same as *Coscinium cribriforme* Prout. With regard to the true *C. cyclops*, I shall hold that it is not known in the rocks of this country. In relation to the generic characters of this species I have only this to say, that every zoœcial feature mentioned by Keyserling (among which I find the lunarium) agrees well with what is found in *C. latum*, Pl. XLIII, fig. 8, shows the perfect zoœcia apertures in *C. cribriforme*.

Coscinium latum Ulrich.

Pl. LXXVI, Fig. 7-7b.

Zoarium growing from an expanded base, attached to foreign bodies, into a flabellate, reticulated frond, from 5 to 10 or more cm. in height and width; consisting of regularly inosculating flattened branches, about one mm. thick and four or five mm. wide. Fenestrules broad oval, 3 or 4 mm. long and 2 to 3 wide, arranged in rather regular intersecting series. Margins of fenestrules and basal portion of zoarium non-celluliferous and very finely granular. Zoœcia apertures arranged in regular, curved, diagonally intersecting series, and in less regular transverse and longitudinal rows. When the specimens are worn the last arrangement is the most obvious; seven to nine rows between the fenestrules. Apertures when well preserved, with unequally elevated peristome, commonly kidney shaped or subpyriform, more rarely, sub-circular, a little larger near the fenestrules than over the central portion of the inosculating branches, varying from 0.15 to 0.25 mm. in diameter on an example in the ordinary state of preservation, six or seven in three mm. measuring diagonally, more than their own diameter apart. Lunarium generally evident, always directed away from the nearest fenestrules. Interspaces solid at the surface, flexuously striated or finely granular; internally occupied by vesicular tissue.

This fine species is the only one known to me from the Lower Carboniferous rocks. It differs from the Devonian *C. cribiforme* Prout, it its wider branches and interspaces, the elevated zoœcia apertures, and in their obvious diagonal arrangement.

Position and locality: Burlington limestone; Calhoun Co., Ill., Quincy, Ill., and Burlington, Iowa.

DICHOTRYPA Ulrich.

(For generic diagnosis see page 386.)

Only one previously described species, the *Fistulipora flabellum*, of Rominger, seems to have the characters ascribed to this genus, yet I do not doubt that when the Palœozoic Bryozoa are more fully worked out, the genus will occupy a prominent place in our classification. Already I can determine seven well marked species, beside fragments of one or two other species from the Keokuk group. The seven described here belong, one to the Niagara, one to the Hamilton, and five to the St. Louis group. The great prominence of the genus in the last formation is a rather peculiar circumstance, since remains of Bryozoa are comparatively rare in these beds.

DICHOTRYPA GRANDIS Ulrich.

Pl. XLII, Fig. 1-1e.

Zoarium a large undulating frond, attaining a height of 13 cm. or more, a width of more than 7 cm., and at hickness of 4 or 5 mm. Surface smooth, but exhibiting, generally, small and inconspicuous solid maculæ. Apertures arranged in bent diagonal series, about seven in three mm. measuring longitudinally or diagonally, with a total absence of ridges, the interspaces being flat. Orifices sub-oval, about 0.15 mm. in diameter, with slightly elevated peristome. Interspaces from one and a half to twice the diameter of the apertures. Zoœcia at first thin-walled, prostrate, commonly of obovate form; with the vestibule tubular and traversing the space to the surface at a right angle with same. Interspaces filled with vesicles, which at first decrease in size outward, and, long before the surface is reached, become filled with solid tissue. Lunarium occupying from one-third to one-half the circumference of the zoœcial boundary, not very conspicuous, but usually with one end projecting tooth-like into the cavity.

This is the strongest as well as the earliest species of the genus known. In its minute structure it seems to compare more favorably with species from the St. Louis limestone than with the Devonian form next described.

Position and locality: Niagara group; Will Co., Ill., near Wilmington.

DICHOTRYPA FOLIATA, Ulrich.

Pl. XLII, Fig. 2-2g.

Zoarium palmate, or an explanate undulating frond. Entire dimensions unknown but attaining a height and width of six or eight cm.; thickness two mm. or less. Surface even, but marked with slightly depressed, circular or elongate, solid maculæ, arranged in more or less regular series, three or four mm. apart measuring lengthwise. Apertures arranged in linear series between longitudinal ridges. These ridges are most prominent in worn specimens; when the surface is well preserved they scarcely show and in this case the arrangement of the cells in diagonally intersecting series, due to their alternation in adjoining rows, is most conspicuous. Apertures circular, 0.12 to 0.15 mm. in diameter, their own diameter or somewhat more apart, about eight in three mm., measuring either longitudinally or diagonally. Peristome a little more elevated on one side than on the other. Primitive zoœcia prostrate, of semi-cordate form, with the vestibule tubular and almost rectangular to the surface. Walls of vestibular portion of zoœcia ring-like, traversed at the posterior side by a small vertical pore. Lunarium very faint. Interspaces filled in the deeper parts of the zoarium with small vesiculæ; as the surface is approached these give way to solid tissue. Superior hemiseptum, when preserved, strong and projecting well into the zoœcial cavity.

This beautiful bryozoan cannot be confounded with any other form known to me from the Hamilton group. The longitudinal arrangement of the zoœcia apertures distinguishes it from other species of the genus.

Position and locality: Hamilton group, Buffalo, Iowa.

DICHOTRYPA ELEGANS Ulrich.

Pl. LXXVI, fig. 8-8*d*.

Zoarium a more or less undulating frond, or palmate expansion, several cm. in width and heighth, 1.5 to 3 mm. in thickness; with the lateral margins sub-acute and non-poriferous. Lower portion of zoarium perfectly smooth, being covered by a dense cortical substance. Above this the surface is marked with circular or sub-stellate solid maculæ, which sometimes crown the summit of low, broad, rounded monticules. Maculæ more or less regularly arranged, about three mm. apart; with the apertures immediately surrounding them, slightly larger than the others: Apertures a little oblique, circular, from 0.11 to 0.16 mm. in diameter, with elevated peristome, usually highest on one side, arranged in regular bent diagonally intersecting series, about once and a half their diameter apart, eight of those in the intermacular spaces in three mm. Interspaces sometimes slightly concave, generally with a faint ridge or ridges, forming sub-polygonal depressed areas around the zoœcia apertures. Internal structure similar to that of the type of the genus, but the primitive portion of the zoœcia is not regular in its form. Just below the surface the inter-zoœcial spaces are more distinctly marked with the intermittent concentric lines.

This species differs from *D. intermedia* and *D. expatiata*, by the smooth lower portion of the zoarium, the sub-stellate maculæ, and the less strongly developed lunarium. From *D. flabellum*, Rominger, and *D. lyroides*, by its different growth.

Position and locality: St. Louis group; Elizabethtown, Ky.; Jersey and Monroe Co.'s, Ill.

DICHOTRYPA INTERMEDIA Ulrich.

Pl. LXXVI, fig. 9-9*c*.

Zoarium sub-ramose, consisting of an explanate frond which throws off at intervals similar fronds, till there is produced somewhat the appearance of several successive fans growing from one another; entire height eight or more cm., width varying from one to three cm.; thickness rarely exceeding 1.5

mm. Margin sharp, with a wide non-poriferous border. Surface smooth, with inconspicuous solid maculæ on a level with or slightly depressed below the general surface, at variable distances apart. Apertures sub-pyriform to sub-circular, 0.12 to 0.15 mm. in diameter, with uneqally elevated peristome, about one and one-half or two times their diameter apart, arranged in diagonally intersecting series, seven or eight in three mm. Internal structure like that of the preceding species, but the vesicles are very crowded vertically and smaller in tangential sections. The solid tissue near the surface is lined longitudinally rather than concentrically. Lunaria pronounced, constituting a conspicuous feature in tangential sections.

This species in its subramose zoarium and better developed lunarium approaches *Cystodictya*. The propriety of referring the species to *Dichotrypa* rather than to *Cystodictya*, scarcely admits of question.

Position and locality: St. Louis group; Alton, Ill.; St. Louis, Mo.

DICHOTRYPA EXPATIATA.

Not figured.

So far as observed, this species closely resembles *D. intermedia* in nearly all its minute characters, but differs so strikingly in the form of the zoarium, that I am inclined to believe that better material than is now at hand, will show corresponding zoœcial differences. The zoaria before me have grown into large thin undulating expansions, one of them (incomplete) being about 15.5 cm. long by 11 cm. wide; its thickness varies from 0.7 to 2.0 mm.

Whether specifically distinct from *D. intermedia* or not, the two forms are easily distinguished, and I have, therefore, thought it desirable that they be known by separate names.

Position and locality: St. Louis group; Alton, Ill.

DICHOTRYPA FLABELLUM Rominger.

Pl. LXXVII, fig. 1-1*b*.

Fistulipora flabellum Rominger, 1866. Proc. Acad. Nat. Sci. Phila. p. 122.

Zoarium having a strong, expanded base, roughly marked on the lower side with a concentrically wrinkled epitheca. On the upper side the base gradually contracts into a flattened or sub-cylindrical stem which soon expands again into a bifoliate, fan-shaped frond, from 1.5 to 4.0 mm. in thickness, and several cm. in width and height. The base, stem, and lower portion of large examples is covered with a faintly striated dermatic crust. Above this the surface presents solid sub-stellate maculæ, four or five mm. apart, bordered by apertures very slightly larger than the rest. In the perfect state the apertures are oval, 0.12 to 0.15 mm. in length, with the lunarium on one side more or less elevated. In the ordinary state of preservation they appear much larger (about 0.2 mm.) and the interspaces correspondingly narrower. The apertures are regularly arranged in intersecting lines, sometimes with six, but more commonly with seven in three mm. Interspaces generally a little elevated, and, when well preserved, covered with fine flexuous striæ. These also occur on the surface of the maculæ.

The flabellate zoarium of this species is such a constant character that it suffices to distinguish it from all others. Wel preserved fragments may be recognized by the striate interspaces.

Position and locality: St. Louis group; Spergen Hill, Indiana, where the specimens are silicified and impregnated with iron.

DICHOTRYPA LYROIDES Ulrich.

Pl. LXXVII, fig. 2-2*b*.

Zoarium a free lyre-shaped frond, with thick rounded solid margins, diverging from a more or less rounded base at an angle of about 60°. The margin is not abruptly thickened, yet is almost twice the thickness of the celluliferous central portion of the frond, which varies in thickness between two and three mm. The height of the example figured must have been at least five or six cm. Surface with broad, rounded, and variously elevated monticules, arranged in diagonally intersecting series, between four and five mm. apart, measuring from center to center. Summits of monticules occupied by solid, circular or sub-stellate maculæ, bordered by a row of apertures a little larger than the rest. Apertures circular, slightly oblique, about 0.14

mm. in diameter with unequally elevated peristome; arranged in more or less regular diagonally intersecting series, about eight in three mm. Interspaces slightly concave, wider than the diameter of the apertures.

The remarkable zoarial habit of this species distinguishes it from *D. flabellum* Rom. and *D. elegans*, its nearest congeners. The silicified specimens upon which the species is founded were collected six or seven years ago by Prof. A. G. Wetherby, and kindly presented to the author. After a cursory examination at the time, I laid them aside under the supposition that they were nothing more than a species of *Lyropora* encrusted by some Fistuliporoid. A more careful second examination has resulted in a very different conclusion.

The thickened support is comparable to the solid base of *Evactinopora* M. & W.

Position and locality: St. Louis group. Southern Kentucky.

ACTINOTRYPA Ulrich.

(For generic diagnosis see page 386.)

ACTINOTRYPA PECULIARIS Rominger.

Pl. LXXVII, fig. 3, 3b.

Fistulipora peculiaris Rominger, 1866. Proc. Acad. Nat. Sci. Phila. p. 123.

Zoarium a thin bifoliate expansion, several cm. in height and breadth, and from 0.5 to 2.5 mm. in thickness. Surface even, provided with subcircular broad maculæ, appearing minutely punctured when a little worn, but granular when well preserved. Maculæ level with the general surface, occurring at rather variable intervals, but an average distance of about six mm. prevails. Apertures regularly arranged in diagonally intersecting series, about six in three mm., floriform, owing to the toothlike projections of the internal ridges, with raised peristomes; about 0.25 mm. in diameter, those nearest the maculæ a little larger. Interspaces of equal or somewhat less width than the diameter of the apertures. Zoœcia at first prostrate, then bent outward almost at right angles. Occasionally the angle at the point of bending is prolonged into a short superior hemiseptum. Soon after bending from 8 to 10 ridges are developed on the inner surface of the zoœcial wall which increase in strength toward the surface. In tangential sections they appear as subregular tooth-like projections into the zoœcial cavity. Interzoœcial space filled with layers of lenticular vesicles, of angular form in tangential sections, which are only partially filled with solid tissue near the surface. Those resting upon the mesial laminæ a little larger than the others.

Rominger states that the species sometimes occurs in unilaminar expansions with an epitheca upon the lower side. I very much doubt the accuracy of this statement, since none of nearly one hundred examples seen by me; are in that condition.

This interesting and peculiar species is the only one known to me having the radial denticles so greatly developed that they form internal septal ridges. Spinose peristomes are known among the FISTULIPORIDÆ, and radial denticles in *Fenestella*, *Polypora* and *Pinnatopora*, but these are all very superficial when compared to the radial structures found in *A. peculiaris*. Still, I regard them all as homologous, and with slight modifications, accounted for by one explanation; Namely, I believe that in *Actinotrypa*, these structures were originally represented by small spines or tubercles on the peristome of the original aperture, which acted as support to converging setæ, and keeping pace with the gradual elongation or growth of the aperture into a tubular "vestibule," they eventually became septa-like ridges.

Possibly the genus has nearer relatives among the FISTULIPORIDÆ, but the essential points of structure, as I now see them seem to correspond more nearly with those of the CYSTODICTYONIDÆ.

Position and locality: Keokuk group; Keokuk, Iowa; LaGrange, Mo., Warsaw and Nauvoo, Ill.

TÆNIOPORA Nicholson, 1874.

(Geol. Mag. N. S. Vol. I, p. 121.)

(For generic diagnosis see page 386.)

Tæniopora occidentalis Ulrich.

Pl. XLII, fig. 3–3c.

This species differs from *penniformis* Nich., a transverse section of which is figured on Pl. XLII, fig. 3d for comparison, in the following points. The zoarium is not so wide, but has a more solid appearance; the median keel is subangular and not nearly so thin nor so prominent, the non-poriferous margin is narrower. The apertures of *T. penniformis* are strongly elevated and arranged in slightly oblique transverse rows (suggesting the name). In this species the arrangement of the apertures in longitudinal series between low rounded ridges is more striking than that in transverse rows, while the peristome is so little developed that it is scarcely perceptible. Internally *T. penniformis* has the interstitial vesicles open, while in the western form they are filled by solid tissue. *T. exigua* Nich., the only other described species of the genus is a smaller form.

The width of the branches in *T. occidentalis*, which bifurcate at intervals of eight mm. or more, is between 2.5 and 3 mm. The zoœcia apertures are subcircular, in four longitudinal rows on each side of the median keel, with from seven to nine in three mm. measuring longitudinally. Their diameter increases from 0.09 mm. in the central rows to 0.13 mm. in the marginal series, the increase being proportional in each succeeding row. A shallow depression is often observed in front of the apertures.

Position and locality: Hamilton group; Buffalo, Iowa.

Prismopora Hall, 1881.

(Bry. Up. Held. p. 17.)

(For generic diagnosis see page 386.)

Prismopora trifolia Rominger.

Pl. LXXVII, fig, 4, 4*a*.

Fistulipora trifolia Rominger, 1866. Proc. Acad. Nat. Sci. Phila. p. 122.

Zoarium consisting of triangular branching stems, growing from a large spreading base attached to foreign objects. The base is traversed by high ridges which frequently coalesce and form large irregular cup-shaped cavities. The dimensions are variable, and the width of the faces varies from 5 to 12 mm., but one of them usually wider than the others. The inequality of the faces is often much increased by pressure. Margins sharp, non-poriferous, essentially parallel. Each face is ornamented by a series of somewhat curved, elongated, slightly depressed maculæ (dimples) extending in a pinnate manner from near the middle of each face to the non-poriferous margin, about three mm. long and one mm. or a very little more wide. The separation of the dimples varies in different examples, but is approximately uniform in each. The specimens figured represent the typical and commonest form. Apertures circular, often a little oblique, about 0.2 in diameter, with more or less elevated peristome, arranged in rows nearly parallel with the dimples, about six in three mm. Interspaces about one-half greater than the diameter of the apertures. Internal structure as required by the genus.

There are probably three species of *Prismopora* in the Keokuk group, which, mainly on account of the indifferent preservation of their fragmentary remains, are now confounded. One of these (represented by fig. 4*b*) has one of the faces very broad, and the dimples widely separated and not extending to the margin. The second has a smoother aspect than the others, the dimples far apart, and the faces subequal. The third is the most abundant, and being identical with authentic examples of *Fistulipora trifolia* Rominger, forms the basis of the above description.

Position and locality: Keokuk group. Abundant at Keokuk, Iowa, LaGrange, Mo., and Warsaw, Ill.

PRISMOPORA MINIMA Ulrich.

Pl. LXXVIII, fig. 1-1*c*.

Zoarium consisting of small, infrequently branching, triangular stems, with the faces subequal, flat or a little concave, and about 1.5 mm. wide. Margins sharp, nearly straight and essentially parallel, with the non-poriferous border mostly narrow, but at irregular intervals much widened to form smooth semi-circular spaces. Apertures sub-circular or transversely ovate, irregularly arranged, about 0.15 mm. in diameter, seven or eight in three mm. Peristome well marked but slightly unequal being most elevated on the lower inner side. In tangential sections the zoœcia are depressed pyriform in shape, the lunarium being well developed. Interspaces quite solid near the surface, but with vesicular of comparatively large size in the central part of the branch.

The small size of its branches distinguishes this species from all previously described. I am indebted to Mr. J. M. Nickles, of Sparta, Ill., for the type specimens, which he washed from the shales near his home. By this method he has brought to light many very interesting species, which on account of their diminutive proportions are easily overlooked when searched for in the ordinary way.

Position and locality: Lower Coal Measures, Sparta, Ill.

Scalaripora Hall, 1881.

(Bry. Up. Held. p. 17.)

(For generic diagnosis see page 387.)

Scalaripora separata Ulrich.

Pl. XLIII, fig. 2.

Zoarium consisting of triangular equilateral stems, each face having a width of about three mm. Margins sharp, nearly straight and parallel. Transverse ridges nearly as far apart as the width of the faces, eleven or twelve in three cm. Portions of face between margins and ridges depressed, celluliferous. Apertures about 0.18 mm. in diameter and less than their own diameter apart; with a faintly elevated peristome; arranged in more or less regular diagonal rows, nine or ten in three mm. Internal structure not observed.

The material at hand is insufficient to determine fully all the characters, but I do not think that collectors will find much difficulty in identifying the species. In this genus the distance between the transverse ridges is a constant character, and serves very well in distinguishing the species. They are separated by wider intervals in *S. separata* than in the two Upper Helderberg forms described by Hall.

Position and locality: Hamilton group, Thunder Bay, Mich.

SCALARIPORA APPROXIMATA Ulrich.

Pl. XLIII, fig. 3.

This species differs from the preceding in being somewhat less robust, the margins slightly serrated and the cell apertures somewhat more approximated. A more striking peculiarity is that the transverse ridges are very close set, there being about twenty in two cm.

Position and locality: Hamilton group; occurs with the preceding at Thunder Bay, Mich.

EVACTINOPORA Meek and Worthen, 1865.

(Proc. Acad. Nat. Sci. Phila. p. 165.)

(For generic diagnosis see page 387.)

This remarkable genus of Bryozoa is known only from the Burlington and Keokuk limestones by three species in the former and one in the latter. The free habit of growth, the radial arrangement of the bifoliate fronds, and the comparatively large proportion of the non-celluliferous areas are the principal peculiarities of the genus. Although very striking, these differences are nevertheless not so important as they may at first appear, since the minute structure and the elemental construction of the zoarium does not depart in any essential point from the plan that prevails in the family. Thus, while in *Cystodictya*, *Dichotrypa* and *Coscinium*, the zoarium consists of two simple folia grown together back to back, and in *Prismopora*, *Scalaripora* and *Glyptopora*, of three such double folia diverging from a central line or axis, these are from four to eight radially arranged double leaves in *Evactinopora*. In the minute structure of the folia there is little or nothing to distinguish the genus from any of the other genera of the family.

EVACTINOPORA RADIATA Meek and Worthen.

Pl. LXXIII, fig. 3, 3*a*.

Evactinopora radiata M. & W. 1865. Proc. Acad. Nat. Sci. Phila. p. 165.

Evactinopora radiata M. & W. 1868. Geol. Surv. Ill vol. 3, p. 502, Pl. XVII, fig. 2*a*, 2*b*.

Evactinopora radiata Ulrich, 1884. Jour. Cin. Soc. Nat. Hist. vol. 7, p. 42, Pl. II, fig. 1-1*e*.

Zoarium ellipsoidal in outline when complete, consisting of from six to eight bilaminar vertical folia, arranged in a radiate manner. In the basal half of the zoarium the folia or rays are united and much thickened by a deposit of carcareous material, so that the "body" of the star, as seen in a basal view, is comparatively strong and the rays correspondingly short and blunt. The edges of the rays are preserved in the regularly rounded base as angular converging ridges, separated by at first very shallow, then gradually deepening and widening furrows. At a point about midway between the summit and base where the rays become free, they are acutely elliptical in transverse section, four or five mm. in width, with a non-poriferous border on each edge, the outer one a little the widest; from this point the margins are parallel for a short distance, then converging slowly, till they meet at the narrowly rounded extremity. The whole base for nearly one-third the distance up the side of the rays, is non-poriferous at the surface, the zoœcia apertures here being covered by a granulo-striate deposit of sclerenchyma, decreasing in thickness upward. Zoœcia prostrate at first, then arising from the mesial laminæ, proceed to each surface of the rays at an angle of about 45°. Apertures subcircular, oblique, the lower margin being most elevated; about 0.22 mm. in diameter, the same distance or less apart, arranged in not very regular intersecting series, with eight or nine in three mm. Interspaces occupied by small lenticular vesicles, a few of which remain open, especially on each side of the mesial plane, the rest being filled and obscured by vertically perforated dense tissue, the perforations appearing in tangential sections as exceedingly numerous minute dark spots. Scattered among them are other spots of large size, that resemble acanthopores, in having the central portion lucid. Lunarium inconspicuous.

Position and locality: Keokuk group. King's Mountain, Ky., and at an undetermined locality in Missouri (M. & W.).

EVACTINOPORA SEXRADIATA Meek and Worthen.

Pl. LXXIII, fig. 2-2*b*.

Evactinopora sexradiata M. W. 1868. Geol. Surv. Ill. vol. 3, p. 502.

This species differs from the preceding in being a little wider and much more depressed, and constant in having only six rays. The zoœcia apertures are also larger, there being only about six in three mm. In a basal view the rays are much longer and more slender. Beside the whole zoarium appears to be much more delicate in its proportions.

The example figured by Meek and Worthen (*loc. cit.*) having only five rays, does not belong to this species, but to *E. quinqueradiata.*

Position and locality: Burlington group. Burlington, Iowa.

EVACTINOPORA QUINQUERADIATA Ulrich.

Pl. LXXIII, fig. 1.

Zoarium with five thin bifoliate rays, varying in different examples in thickness from 2 to 4 mm., in width from 20 to 60 mm., and in height from 15 to 40 mm. The body formed by the union of the rays comparatively very small. Rays increasing very gradually in thickness from the free outer margin to the body, sharp on the lower margin, which curves very slightly upward toward the extremity, where it forms nearly a right angle with the more curved upper margin. Zoœcia apertures small, sub-circular, about twice their width apart, arranged in regular intersecting series, about six in three mm.

This species is readily distinguished from *E. sexradiata*, M. & W., by its much larger size, five instead of six rays, and comparatively more depressed form.

A section in the rock showing only the upper portion of the rays of an example of this species was erroneously figured in Vol. III, on plate XVII, as *E. sexradiata*, by the authors of that species.

Position and locality: Burlington limestone. Burlington, Iowa, and Montezuma, Ill.

EVACTINOPORA GRANDIS Meek and Worthen.

Pl. LXXIII, fig. 4.

Evactinopora grandis M. & W. 1868. Geol. Surv. of Ill. vol. III, p. 503. Pl. XV, fig. 2*a*, 2*b*.

This species, like *E. quinqueradiata*, has very much larger rays than the other species. They attain in the largest examples a width of eight cm., but in a small specimen before me, they are only four cm. wide. Their entire height has not been observed, but I do not think it was as great as the width; their greatest thickness varies from 4 to 8 mm., and the taper to the outer extremity is very gradual. Far up, the axis is rhombic in shape, and the rays are very much contracted immediately after leaving the axis. The rays are four in number, extending out at right angles to one another. Zoœcial tubes oblique, the apertures small, round, regularly arranged in quincunx, separated by interspaces about equal to twice their diameter; five or six in three mm.; interspaces filled with vesicular tissue, the vesicles open except near the surface, where they are as usually filled with a deposit of sclerenchyma.

There are several peculiarities in the minute structure, but the preservation of the Bryozoa in the Burlington limestone is rarely so satisfactory that they can be determined.

Luckily the basal portion of the zoarium usually holds together, so that the three species found in this rock can be distinguished by the number and form of the rays.

Position and locality: Burlington limestone, Burlington, Iowa.

GLYPTOPORA Ulrich, 1884.

(Jour. Cin. Soc. Nat. Hist. Vol. VII, p. 39.)

(For generic diagnosis see page 387.)

During the preparation of this work I have had an abundance of material for study, and in many instances I have been enabled to give a better definition of genera previously proposed by me. This genus required perhaps more time than any other to master fully. The principal difficulty was encountered in the determination of the method of growth of such forms as *G. keyserlingi* and *G. punctipora*. The fragmentary remains, though abundant, proved very deceptive, and it was only after much search that zoaria sufficiently complete to show the plans were obtained. After this point was determined it became clear that the genus was divided into two unequal groups. In the smaller one, containing only *G. plumosa* and *G. sagenella*, with its two varieties, the zoarium forms an irregular bifoliate expansion, having both surfaces divided into larger or smaller cup-shaped cavities by the bifurcation and coalescing of the sharp-edged high ridges. These ridges are composed of two layers of zoœcia grown together back to back. The other group comprises the balance of the species, excepting, *G. michelinia*, which is intermediate, its zoarium being primitively unilaminar as in this group, while the upper surface of the expansion is precisely like that in the first section. In *G. keyserlingi* and the other species the zoarium differs from that of *G. sagenella* in having the ridges developed to such an extent that they form large bifoliate expansions. These diverge from a small basal expansion, covered on the lower side by a strongly wrinkled epitheca.

The identification of Prout's species was another difficult task, but, at last, all were known with the exception of his *Coscinium wortheni*. No species is known to me that is strictly identical with the figure given in Vol. 2 of these reports. I am, however, strongly inclined to regard the species as founded upon the basal portion of *G. keyserlingi*. An examination of the original specimens alone can determine the point beyond dispute.

GLYPTOPORA PLUMOSA Prout.

Pl. LXXVIII, fig. 3-3*c*.

Coscinium plumosum Prout, 1860, Trans. St. Louis Acad. Sci. vol. I, p. 572.

Coscinium plumosum Prout, 1866. Geol. Surv. Ill. vol. II, p. 414. Pl. XXII, fig. 3, 3*b*.

Zoarium consisting of one or more bilaminar thin expansions, arising from a common attached base, each having both surfaces traversed by strong bifurcating and coalescing ridges, so as to enclose large but rather shallow concave spaces or cups, varying so far as observed, in length from 20 to 30 mm., and in width from 12 to 32 mm. The surface of the cups slopes gradually up to the base of the sharp edged ridges. At the bottom there is usually a long and narrow depressed macula or "dimple," and on each side arranged in a more or less distinctly pinnate manner, are a series of long, curving, sharply depressed, parallel dimples, about 1.2 mm. wide, and from 7 to 16 mm. long.

The ridges on one side of the expansion correspond to the central depressions on the other. Zoœcia apertures very slightly oblique, sub-circular or oval, 0.15 to 0.20 mm. in diameter, arranged in from four to eight (usually five) alternating rows between the dimples, about nine in 3 mm. Peristome moderate, somewhat more elevated on one side than on the other. Interspaces depressed when perfect, usually about half as wide as the apertures. In thin sections the zoœcial tubes have moderately thick ring-like walls, a portion of the wall being distinguishable from the rest as the lunarium by its lighter color. A large number of small vesicles occupy the interspaces between the zoœcia walls.

The specimen originally figured by Dr. Prout was apparently somewhat crushed, and scarcely shows the characteristic plumose arrangement of the dimples. He also describes and illustrates the form here described as *G. sagenella* var *caliculosa*, as the opposite or "cupuliferous" side of *G. plumosa*. This is evidently a case of faulty observation since the two sides of the expansion are approximately alike.

Position and locality: Warsaw beds. Rather rare at Warsaw, Ill., and Barrett's Station, St. Louis Co., Mo.

GLYPTOPORA SAGENELLA Prout.

Pl. LXXVIII, fig. 6, 6*a*.

Coscinium sagenella Prout, 1859. Trans. St. Louis Acad. Sci. vol. I, p. 573.

Coscinium sagenella Prout, 1866. Geol. Surv. Ill. vol. II, p. 415, Pl. XXII, fig. 5, 5*a*.

Zoarium erect, higher than wide, the dimensions varying with age, the largest seen being about eight cm. high and four cm. in its greatest width. Both sides with strong sharp ridges, dividing and coalescing so as to enclose concave depressions or "cups." The principal ridges at any rate, always correspond with a depression on the opposite side, and have a more or less decided longitudinal arrangement. The cups, especially the central ones, are several times longer than wide, both dimensions being very variable in even the same example. Generally those near the lateral margins of the zoarium are shorter and directed outward. The length of the depressions so far as observed, varies from 4 to 30 mm., the width from 3 to 7 mm., the depth from 1 to 2.5 mm. Summit of ridges sharp, and non-poriferous. Surface of cups with rather inconspicuous elongated maculæ, which are somewhat depressed and best shown in the examples with the shortest cups. Zoœcia with sub-circular apertures, surrounded by an unequally elevated peristome, about 0.18 mm. in diameter, an equal or less distance apart, and averaging eight in three mm., with no recognizable plan of arrangement. Zoœcial tubes with thin walls, at first prostrate along the mesial plate and somewhat flattened, then bending with a moderate curve and becoming rounded, proceed to the surface at an angle varying somewhat from the perpendicular. A few diaphragms occasionally developed in the tubes. Lunarium present but not always showing plainly. Vesicles variable in shape and size, shallow, their width almost equal to the diameter of the tubes, those along the median lamina larger than the others. There is a thin deposit of light colored sclerenchyma upon their floors.

In its typical form this species is readily distinguished from all the others by the elongated "cups." The two forms next described are likewise easily recognized when typical, but as we sometimes meet with examples which seem to combine the characters of two or even all three, I have thought it best to indicate their intimate relations by giving them only the rank of varieties under *G. sagenella*.

Position and locality: Keokuk group, at Bentonsport, Iowa; Warsaw beds, at Warsaw, Ill.

GLYPTOPORA SAGENELLA var. CALICULOSA Ulrich.

(Not figured.)

In this variety the zoarium is wider, more lax, and has a more delicate aspect than in the typical form of *G. sagenella*, the ridges are thinner, being abruptly elevated from the nearly flat bottom of the cups. The cups are also much shorter, many of them being hexagonal in outline and but little longer than wide. In an average example their dimensions may vary as follows: the width from 3 to 7 mm.; the length from 5 to 10 mm.; the depth from 1.5 to 2.5 mm. The dimples are also much better defined and more depressed, one placed near the center of the cup being especially distinct and generally of elongate stellar form. A number, varying with the size of the cup, are arranged in a subradial manner around the central one, and extend up the steep slopes of the ridges to the sharp non-poriferous edge. The zoœcial apertures are also shown more closely approximated.

Position and locality: Warsaw beds. Common at Warsaw, Ill. A small example of this variety is figured in Vol. 2 of this Survey, as the opposite side of *Coscinium plumosum* Prout, obviously in error.

GLYPTOPORA SAGENELLA var. LATA Ulrich.

Pl. LXXVIII, fig. 4.

This variety differs from typical *G. sagenella* in very nearly the same manner as does the var. *caliculosa*, its principal peculiarities being the much wider cup and the more elongated and often curved dimples. The figure represents one side of an average example.

Position and locality: Warsaw beds. Not rare at Warsaw, Ill.

GLYPTOPORA MICHELINIA Prout.

Pl. LXXVIII, fig. 8-8*b*.

Coscinium michelinia Prout, 1860. Trans. St. Louis Acad. Sci. Vol. I, p. 573.

Coscinium michelinia Prout, 1866. Geol. Surv. Ill. Vol. 2, p. 414, Pl. XXII, fig. 4, 4*a*.

Zoarium encrusting or free, with a wrinkled epitheca on the lower side. Upper surface divided into larger or smaller, deep, polygonal, cup-shaped cavities, enclosed by prominently elevated, sharp ridges, the summits of which, when in a good state of preservation, are serrated. The cups vary greatly in size, but are approximately equal on each example. The average width in the two largest specimens seen is about 12 mm., while in others it is only about 9 mm. At the bottom of the cups there is a more or less elongated depressed solid macula. Similar narrow maculæ extend up the sides of the ridge at intervals apart of 2 mm. more or less. These maculæ usually occupy corresponding positions on each side of the ridges, and being depressed terminate before reaching their summits. The serrated character of the comb of the ridge is due to this circumstance. The spaces between the maculæ is uniformly occupied by the zoœcia apertures. These are sub-circular, about 0.16 mm. in diameter, and nine in 3 mm., separated by interspaces equal in width to their diameter.

The upper surface of this peculiar species closely resembles the varieties of *G. sagenella*. Yet there is an important difference in their respective modes of growth. In that species the zoarium is celluliferous on both sides, while in this the lower surface is covered with an irregular epitheca. In other words one may be said to be bifoliate, the other simple and lamellate. The zoarium of *G. michelinia* also attains a much greater thickness than any of the other species of the genus, the greatest observed being about 10 mm.

Position and locality: Warsaw beds, Warsaw, Ill., and Barrett's Station, St. Louis Co., Mo.

Glyptopora pinnata Ulrich.

Pl. LXXVIII, fig. 2.

Of this species I have seen only the imperfect example figured. Judging from this the species must have been on the order of *G. keyserlingi* Prout, and *G. megastoma* Ulr. At the junction of the foliar expansions the zoarium is strong and of triangular form in transverse section. The zoœcia apertures extend uniformly over this portion, there being no non-poriferous strip. The maculæ are solid and regularly arranged in diagonal series, and in a pinnate manner on each side of the line of junction of the leaves. They are somewhat elevated, but this may be due to the wearing away of the intermediate spaces. Diagonally they are about 5 mm. apart, measuring from center to center. The zoœcia are similarly arranged, about ten in 5 mm., with comparatively large sub-ovate apertures, about 0.35 mm. in diameter, separated by thin interspaces. In better preserved specimens the apertures would probably be smaller and the interspaces correspondingly thicker.

The species must be closely related to *G. megastoma*, of the Keokuk group.

Position and locality: Burlington limestone. Sagetown, Henderson Co., Ill.

GLYPTOPORA KEYSERLINGI Prout.

Pl. LXXVIII, fig. 4-4*b*.

Coscinium keyserlingi Prout, 1858. Trans. St. Louis Acad Sci. vol. I, p. 269, Pl. XV fig. 4-4*a*.

?*Coscinium wortheni* Prout, 1860. Ibid vol. I, p. 571.

?*Coscinium wortheni* Prout, 1866. Geol. Surv. Ill. vol. 2, p. 412, Pl. XXII, fig. 1, 1*a*.

The complete zoarium consists of thin upright bifoliate expansions, arranged in such a manner that they enclose large and rapidly expanding hexagonal cups. The under side of the dome-shaped or flattened base is covered with a wrinkled epitheca, and the bifoliate fronds which extend up from it are equivalent to the ridges in *G. michelinia*. At the angles of junction of the fronds, which vary in thickness from 0.25 to 1.0 mm., there is a narrow depressed solid strip on each side, making the junction very frail. In consequence it is only in extremely rare instances that the foliate expansions are found joined together, and in nine cases out of ten we deal only with fragments of one of the sides or partitions of the cups. Figure 4 represents a small but nearly complete side, and shows the form and distribution of the lanceolate or acutely elliptical dimples and zoœcia. Its width is comparatively greater than usual, the angle formed by the two non-poriferous edges being a little over 90°. In other examples the angle varies from that degree down to 50°. The dimples are from 4 to 6 mm. long, 1.5 to 2.0 wide, and generally a little the widest in their upper half, and somewhat acutely terminated below. Their surface as well as the non-poriferous margins are marked with fine granulose, longitudinal striæ. Apertures irregularly sub-circular or oval, oblique, with strongly projecting irregularly toothed hood, the average about 0.2 mm. in diameter, those bordering the dimples somewhat larger; from ten to twelve occur in 5 mm., measuring along the moderately regular diagonal and longitudinal series. Interspaces somewhat rough, depressed, usually of less width than the apertures. In thin sections the zoœcial tubes are thin-walled, at first prostrate; after bending they continue in a somewhat oblique course to the surface. Vesiculæ small, very numerous, filled up with solid tissue towards the surface.

Position and locality: Keokuk group. Rather common at Warsaw and Nauvoo, Ill.; Keokuk and Bentonsport, Iowa, and at other localities.

Glyptopora elegans Prout.

Pl. LXXVIII, Fig. 10-10e.

Coscinium elegans Prout, 1860. Trans. St. Louis Acad. Sci. Vol. 1, p. 572.

Coscinium elegans Prout, 1866. Geol. Sur. Ill., Vol. 2, p. 413. Pl. XXII, Fig. 2-2a.

In this species the growth and general construction of the zoarium is precisely as in *G. keyserlingi*, from the Keokuk group. The only differences so far observed are, (1) that the cups are more numerous, proportionally smaller, and the bifoliate partitions narrower; (2) the dimples prevailingly narrower, and (3) the zoœcia apertures are smaller, their diameter varying from 0.15 to 0.2 mm., with from 12 to 14 in 5 mm. The smaller size of the apertures is the most important as well as the most constant of the differences.

Position and locality: Warsaw beds at Warsaw, Ill.

Glyptopora megastoma Ulrich.

Pl. LXXVIII, Fig. 5-5a.

In its manner of growth and general appearance this species resembles *G. keyserlingi* Prout, but the following points of difference are so obvious that there is little danger of confusion between them. The dimples or maculæ are shorter and not depressed, sometimes even occupying the summits of broad elevations. The zoœcia apertures are direct and sub-circular in outline, with the lunarial side usually somewhat straightened and pinched in the middle, the peristome thinner and sub-equally elevated, the apertures considerably larger, those of the average size being about 0.25 mm. in diameter, while some of those in the immediate vicinity of the maculæ are frequently 0.4 mm. in width. Nine and one-half or ten of the ordinary zoœcia apertures occur in 5 mm, At the junction of the leaves they are somewhat thickened and there is no narrow depressed non-poriferous strip at the line of junction. The interspaces and maculæ appear rather coarsely granular or pitted at the surface. Internally they are occupied by larger and fewer vesicles. These differences seem amply sufficient to distinguish the two species. A nearer congener is probably found in *G. pinnata* of the Burlington limestone.

Position and locality: Keokuk group. Occurs at Warsaw and Nauvoo in Ill., and Keokuk and Bentonsport in Iowa.

GLYPTOPORA PUNCTIPORA Ulrich.

Pl. LXXVIII, Fig. 9-9a.

In the manner of growth and general aspect this species is precisely like *G. keyserlingi*, and *G. elegans*, with the single exception that the maculæ or dimples are smaller, and very little impressed, usually appearing on a level with the general plane of the surface. They are consequently a much less conspicuous superficial feature than in those species. The zoœcial apertures are small, compressed, somewhat kidney-shaped, the longer diameter about 0.2 mm.; arranged in regular curved diagonally intersecting series, 11 or 12 in five mm. The apertures occupy the summits of rounded confluent pustules, which are a little the largest in the vicinity of the maculæ. The width of the interspaces usually equals about one and a half times the long diameter of the apertures. In sections the zoœcia are thin-walled, the lunarium fairly distinct, the vesicles numerous and generally in two series between the zoœcia. Several sections show very plainly the minute perforation in the vesicle covers.

Fragments of this species might be confounded with a St. Louis limestone species of *Dichotrypa*, but the nearly complete example before me clearly proves the species to be a *Glyptopora.*

Position and locality: Chester group. Rare at some locality in Monroe Co., Ill.

EURYDICTYA Ulrich.

(For generic diagnosis see page 389.)

This genus includes a small group of Silurian Bryozoa that, though intimately related to *Stictopora* Hall (*Rhinidictya* Ulrich), it seems desirable to distinguish from that genus. The broad and undefined zoarial expansion pertaining to the several species gives to them a very different aspect from that presented by the parallel margined, dichotomously divided, narrow stipes, so strictly adhered to by the true species of *Stictopora.* The two genera stand precisely in the same relation to each other as *Cystodictya* and *Dichotrypa.*

In addition to the three species here defined the genus will include *Phænopora multipora* Hall, of which a full description is given in my "American Palæozoic Bryozoa," (Jour. Cin. Soc. Nat. Hist., vol. V, p. 171). At that time I stated the species was most probably not congeneric with typical *Phænopora* Hall. That supposition has since been verified.

EURYDICTYA CALHOUNENSIS Ulrich.

Pl. XXX, Fig. 4-4c.

Zoarium an expanded frond; thickness two mm. Surface smooth with maculæ which are irregular in size, elevation, and distribution. Zoœcia arranged in longitudinal series; the superficial apertures have the appearance of being between raised longitudinal lines; generally oval, occasionally sub-circular, between six and seven in two mm. measuring lengthwise. Interspaces between the ends of two successive apertures about equal to or less than the long diameter of the apertures. Minute tubuli, appearing on the surface as granules, are arranged in a flexuous line between adjacent series of cells and in one or two irregular rows in the end interspaces. Maculæ consist of a large number of these minute tubuli. Superior hemiseptum very pronounced. This form in common with some others shows a secondary layer growing upon the primary layer of cells, but growing in reversed order, zoœcium above zoœcium, and maculæ above maculæ. This is best observed in longitudinal sections (fig. 4c).

Externally this species resembles *E. multipora* Hall, but the cell apertures are more rounded, and the internal structure is very different. Internally it is considerably like *E. montifera*, but the pronounced monticules of that species are sufficient without other points of difference to distinguish the two.

Position and locality: Trenton group; Port au Gres, Calhoun Co., Ill.

Eurydictya montifera Ulrich.

Pl. XXX, Fig. 3-3d.

Zoarium an expanded frond, several cm. in height and breadth and 0.15 to 0.20 mm. in thickness. Surface provided with conspicuous monticules having solid apices, and with no marked arrangement, two or three mm. apart. Primitive portion of zoœcia very short, vestibular portion of tube almost at right angles with the surface. Vestibules 0.15 to 0.18 mm. in diameter, inter-vestibular space about the same as the diameter of the vestibules. Apertures oval, from 0.15 to 0.22 mm. in their long diameter, nine longitudinally and ten diagonally in three mm., arranged in longitudinal and diagonally intersecting series. Zoœcia surrounded by a single row which sometimes becomes doubled at the angles, of minute tubuli, appearing on the surface as granules. The maculæ are composed of a large number of these minute tubuli having an indefinite radial arrangement. Occasionally there is a superposed layer growing in the reversed direction. Superior hemiseptum rather pronounced.

In some respects this species is closely related to *E. calhounensis*, but is readily distinguished from that form by the smaller, and differently arranged median tubuli and the montiferous surface. The zoœcia of that species also have a dark band surrounding the visceral cavity; this band is wanting in *E. montifera*.

Position and locality: Cincinnati group, Wilmington, Ill.

Eurydictya sterlingensis Ulrich.

Pl. XXX, Fig. 2-2a.

Zoarium an irregular frond, sometimes appearing to branch. Surface smooth, destitute of maculæ. Zoœcia arranged in very regular longitudinal and diagonally intersecting series. Apertures round, about 0.12 mm. in diameter, six vertically and seven diagonally in two mm.; separated by very wide interspaces, about 0.20 mm. wide, which are filled with a great number of minute granules arranged in several series about each aperture.

The form of growth of this species is like that of *E. multipora* Hall, but that species has the interspaces very narrow, and cells so arranged as to appear between elevated longitudinal ridges, while the minute tubuli form a longitudinal line between the adjoining vertical series of apertures and never occupy the end interspaces.

Position and locality: Cincinnati group, Sterling, Ill.

Pachydictya Ulrich, 1882.

(Jour. Cin. Soc. Nat. Hist. Vol. V, p. 152.)

(For generic diagnosis see page 390.)

This genus proves to be one of the most important divisions of the lower Palæozoic Bryozoa. The three species that were known to me when the genus was proposed, have since been reinforced by nineteen others, varying in time from the base of the Trenton to the Lower Helderberg. The form of the zoarium varies greatly in the different species, some being narrow ribbon-like, a few wider and stronger, while others again form broad undulating expansions of considerable thickness. In all, however, the minute structure is remarkably constant. The extremes in this respect so far noticed, are furnished by the five species here described. The structure of *P. robusta* Ulr., the type of the genus, is intermediate between that of *P. everetti* and *P. firma*, while that of *P. gigantea*, is very much like that of *P. acuta* Hall, *P. occidentalis* Ulr., *P. obesa* Foerste, and several other species. *P. splendens* suggests *Eurydictya*, but not very strongly.

PACHYDICTYA EVERETTI Ulrich.

Pl. XXXIII, fig. 1–1f.

Zoarium an undulated frond, several cm. in height and width, three mm. or a little more in thickness. Surface smooth, destitute of maculæ. Cell apertures suboval to hexagonal in shape, forming diagonally intersecting as well as longitudinal rows, from 0.18 to 0.25 mm. in longitudinal diameter, about five in two mm. diagonally, and four longitudinally. Occasionally a cell aperture has preserved an opercular structure. Zoœcial tubes rather thin-walled, largely in contact, with no straight or flexuous lamella separating them, provided with closely set diaphragms. The interstitial vesicles are angular, comparatively few, mainly occupying the angles between the zoœcia and remaining so far as observed, open to the surface. In deep tangential sections the walls are exceedingly thin and appear to contain a series of exceedingly minute tubuli. The minute tubuli between the median laminæ of the frond are a more decided structure than in any other species of the genus yet examined.

This species preserves all the essential characters of the genus, yet the open interstitial spaces and the great abundance of diaphragms are curious features. The smooth surface unmarked with maculæ, and the regular and comparatively large sized sub-angular cells distinguish it from other species of the genus.

Position and locality: Trenton group; Dixon, Ill.

PACHYDICTYA SPLENDENS Ulrich.

Pl, XXXI, fig. 2g, and Pl. XXXII, fig. 1–1b.

Zoarium consisting of undulated flabellate fronds, or of broad irregular dividing branches, 1 to 3 cm. wide, as much as 15 cm. high, and 4 mm. or less in thickness. Surface smooth with scarcely noticeable clusters of cell apertures separated by thicker interspaces and a little more prolonged than ordinarily. Cell apertures oblique, narrowing toward the upper end, with peristome or lip upon the lower margin, arranged in longitudinal and diagonally intersecting lines, the longitudinal arrangement most prominent. Apertures six longitudinally, seven and a half diagonally in two mm., from 0.16 to 0.2 mm. in longitudinal diameter. Zoœcial tubes at first prostrate, then bending outward proceed to the surface at an angle of 45°; provided with two or three diaphragms. Interzoœcial spaces at first occupied by a vesicular structure which is soon afterwards replaced by solid calcareous tissue, pierced by minute tubuli; the latter are arranged very closely in a flexuous line, and at the surface appear as minute granules occuping the ridges between the longitudinal series of cells; also found in the end spaces.

This species is intermediate in its characters between *P. firma* and *P. gigantea*. From both it differs in the obliquity of the cell apertures, from the former in the absence of monticules or distinct maculæ, in having longer and somewhat larger cells, and the median tubuli arranged in regular flexuous lines, from the latter in having much thinner walled zoœcia, and somewhat different growth.

Position and locality: Cincinnati group; very abundant at Wilmington, Ill.

Pachydictya gigantea Ulrich.

Pl. XXXI, fig. 3—3e.

Zoarium a very large undulated frond, the type specimen which is not complete, being 10.5 cm. in height, 5 cm. in its greatest width, and about 3.0 mm. in thickness. Surface with maculæ, arranged in more or less regular series, sometimes broad and low, usually level with the general surface, occasionally a little depressed, about three mm. apart. Apertures arranged with great regularity in longitudinal and diagonal series, approximately oval, surrounded by a slightly elevated peristome, from 0.15 to 0.25 mm. in their longest diameter, those immediately surrounding the maculæ being the largest with about eight in three mm. longitudinally. Zoœcial tubes but little prostrate at their origin, curving outwards in their course to the surface, where they open with nearly direct apertures; walls thick, ring-like; two or three diaphragms developed. Interzoœcial space at first occupied by vesicular tissue, which afterwards becomes obsolete. In tangential sections the minute tubuli are quite inconspicuous (only in longitudinal series), and the maculæ have a solid appearance.

The large subfrondescent growth, and thick ring-like walls, distinguish it with other characters from *P. splendens* and *P. firma*.

Position and locality: Cincinnati group; Wilmington, Ill.

PACHYDICTYA FIRMA Ulrich.

Pl. XXXI, fig. 2—2f.

Zoarium consisting of usually twisted, compressed branches, 5 to 10 cm. in height, 10 to 15 mm. in width and 5 to 8 mm. in thickness. Transverse section lenticular. Surface generally marked with small, conical monticules, with solid apices, arranged in quite regular diagonal intersecting series. Zoœcial tubes gradually curving outwards until they are nearly direct at the surface, provided with an occasional diaphragm. Zoœcia surrounded by one or two series of minute tubuli which appear as granules upon the surface when well preserved. Apertures with but little regularity of arrangement, sometimes subcircular, usually oval, from 0.15 to 0.20 mm. in diameter, about six in two mm. measuring lengthwise. Maculæ subsolid with a variable number of minute tubuli aggregated in them. Interzoœcial space provided in the deeper portions with vesicular structure. This is afterwards replaced with solid calcareous tissue.

The comparatively thick branches, small pimple-like monticules, large number of granules, and lack of orderly arrangement of the apertures, (though sections show the zoœcia to be arranged in longitudinal series), are the most marked characters of this species. In the width of the branches it resembles *P. robusta*, but ample differences in cell arrangement distinguish them.

Position and locality: Cincinnati group, Wilmington, Ill.

PACHYDICTYA FENESTELLIFORMIS Nicholson.

Pl. XXXI, fig. 1.

Ptilodictya fenestelliformis Nich., 1875. Ann. & Mag. Nat. Hist. 4 ser. Vol. 5, p. 181. Pl. XIV, fig. 5—5b.

Ptilodictya fenestelliformis Nich., 1875. Pal. Ohio, Vol. II, p. 263, Pl. XXV, figs. 8, 8b.

Ptilodictya fenestelliformis Nich., 1875. Rept. Pal. Ontario, p. 14.

Phænopora fenestelliformis Ulrich, 1882. Jour. Cin. Soc. Nat. Hist. Vol. V, Pl. VIII, fig. 8.

This species is exceedingly abundant at Wilmington, Ill. Its ramose habit of growth and comparatively small branches distinguishes it from the four species of the genus with which it is associated, one of them still undescribed.

The figure represents a small but nearly complete example of a variety which I propose to call *corticula*, from the fact that the zoœcia apertures of the lower half or more of the zoarium are covered by a more or less thick, and finely granulose or striate, solid deposit. The zoarium of the variety is larger and the branches wider and much stronger than in the typical form. In both the surface exhibits sometimes conspicuous, at the other times faintly defined smooth spots. The zoœcia apertures are small, widely separated, surrounded by a peristome, ranged in longitudinal rows, with twelve or thirteen in 5 mm. The internal structure is similar to that of *P. gigantea.*

P. fenestelliformis and its var. *corticula*, belong to a group of closely related species, comprising, besides, *P. acuta* Hall and *P. occidentalis* Ulr., from the Trenton, and *P. bifurcata* VanCleve (Hall) and *P. turgida* Foerste, from the Clinton.

Position and locality: Cincinnati group, Wilmington, Ill.

EUSPILOPORA Ulrich.

(For generic diagnosis see page 389.)

EUSPILOPORA SERRATA Ulrich.

Pl. XLIII, fig. 4—4h.

Zoarium a narrow stipe, branching dichotomously as a rule, with serrate margins, width about two mm., thickness 0.8 mm.

attached to foreign bodies by a slightly expanded base. Cell apertures arranged in four or five longitudinal series, occupying the center of the branch, sending off alternate lateral series, composed of three or four irregular rows extending to the margins. Between these lateral series are concave granulo-striate non-celluliferous spaces. The elevated ridges between the longitudinal series bear a considerable number of blunt spines. Cell apertures about seven in two mm. measuring down the rows; oval, about 0.10 mm. in longer diameter; width of end spaces about one and a half times the diameter of the apertures. Zoœcial tubes prostrate for a short distance, then abruptly bent outward. Between the zoœcia are vesicles or mesopores, which do not show at the surface and are provided with very thick diaphragms. The interspaces between the zoœcia and the non-celluliferous portions are occupied by exceedingly numerous minute tubuli.

The peculiar arrangement of the zoœcia distinguishes this species from all Stictoporoid Bryoza known to me from the Hamilton group, with the exception of *Stictopora palmipes* Hall. That species, if I have correctly identified it, is closely allied to the one above defined, and clearly congeneric with it. It differs in being wider and scarcely branched, nor have I found it at Buffalo, Iowa, where *E. serrata* is fairly abundant.

These species I regard as quite distinct from *Stictopora*, the minute structure and the arrangement of the zoœcia being very different from what we find in typical species of that genus. The following species does not belong in this association, but is provisionally placed here till we can find a more fitting receptacle for it.

EUSPILOPORA ? BARRISI Ulrich.

Pl. XLIII, Fig. 5-5d.

Zoarium dichotomously branched, stipe with non-celluliferous margins, from two to four mm. wide, and one to four mm. in thickness. Transverse section strongly double convex. Apertures sub-polygonal or sub-circular, slightly oblique, 0.2 mm. or a little less in diameter, between eight and nine in three mm., rather irregularly arranged. Interspaces considerably less than the diameter of the apertures in the central portion, but greater towards the margins of the stipe. Zoœcial tubes long, oblique from their origin to the surface. Interzoœcial space appearing granular; under a higher power resolved into a very large number of exceedingly minute tubuli. Mesial lamina wavy in transverse section, and scarcely distinguishable.

This species is only provisionally placed with *Euspilopora*. It presents some points of resemblance to the Silurian genus *Phyllodictya*, but differs too strongly in other respects to admit of its being referred there. It probably belongs to an undescribed genus, but being unwilling to found a new genus upon unsufficient material, I prefer to arrange the species as above till more of the numerous Hamilton species have ben thoroughly investigated.

I am indebted for the fine specimen figured to the Rev. W. H. Barris, of Davenport, Iowa, in whose honor the specific name is given.

Position and locality: Hamilton group, Buffalo, Iowa.

Tæniodictya Ulrich.

(For generic diagnosis see page 393.)

Tæniodictya ramulosa Ulrich.

LXVII, Fig. 1-1b.

Zoarium a flexuous, dichotomously branching stipe, of considerable height, 2 or 3 mm. in width and less than 1 mm. in thickness, increasing in width before bifurcating, with essentially parallel margins; attached by a small expanded base. Bifurcations numerous, taking place at intervals of from 5 to 10 mm. Cell apertures arranged in longitudinal and curved diagonal series, the longitudinal arrangement more pronounced in the center and the curved arrangement towards the margins; about six in 2 mm. longitudinally; the oval apertures occupy the bottoms of sloping areas; the latter are more or less confluent, sometimes hexagonal in outline, smallest in the central rows, gradually increasing in size toward the rather wide, punctate or finely striate margin.

Position and locality; Keokuk group; Keokuk, Iowa; Nauvoo, Warsaw and other localities in Illinois. A common and characteristic species.

var. BURLINGTONENSIS Ulrich.

Pl. LXVII, Fig. 2-2b.

The two specimens figured are from the Burlington limestone at Burlington, Iowa, and agree very closely with the *T. ramulosa*, but are somewhat more robust. The cell apertures appear to have been a little more circular and the sloping areas surrounding them are never confluent so far as observed. The material is not in condition to furnish good thin sections, so that the internal characters could not be compared. One specimen is an anastomosing form and may not belong here.

TÆNIODICTYA FRONDOSA Ulrich.

Pl. LXVII, Fig. 5, and Pl. LXIX, Fig. 5-5c.

Zoarium an expanded frond, a cm. or more in height and width, and one-half mm. or more in thickness. Surface nearly even, marked with clusters, something more than their own diameter (1.5 mm.) apart composed of larger sized cells. At the center of the clusters is often found a greater or less aggregation of small openings (mesopores?). Cell apertures in more or less regular, diagonally intersecting series, sub-circular, with moderately thick interspaces, seven or eight of the average size in 2 mm., those in the clusters from one-third to one-half larger than the others. Inter-apertural spaces ridge-like, with the central portion sub-angular, and when in a good state of preservation bearing minute granules. Zoœcia prostrate, the vestibule almost direct to the surface. In a tangential section the space along the middle of the zoœcial partitions exhibits a large number of irregularly arranged minute dark spots, which only in rare and very limited instances arrange themselves in transverse lines.

The mode of growth and cell arrangement as well as the irregular disposition of the intra-zoœcial dots distinguish *T. frondosa* from the other species of the genus.

Position and locality: Keokuk group, Keokuk, Iowa.

Tæniodictya cingulata Ulrich.

Pl. LXVII, Fig. 3-3b.

The only specimen examined of this species is a very large, more or less dichotomously branched stipe, three to five mm. wide. The specimen is split through the center, showing one side of the median lamina. Celluliferous face imbedded in the matrix and not seen. The arrangement of the zoœcia as shown by thin sections, though similar to that of *T. ramulosa*, differs in having the diagonal lines straighter and more pronounced; diagonally about eight in two mm., longitudinally six in the same space. The zoœcia are elongate-hexagonal, the outlines being formed by a transversely lined interspace.

In *T. ramulosa*, this lined interspace does not surround the zoœcia, but continues as a flexuous band between the longitudinal series of cells. The present species is further distinguished by its wider branches.

Position and locality: Keokuk group; Warsaw, Ill.

Tæniodictya subrecta Ulrich.

Pl. LXVII, Fig. 4-4d.

Zoarium an erect stipe, branching dichotomously; angles between branches about thirty degrees; width of branches between 2 and 3 mm., slightly less immediately after each bifurcation. Cell apertures oval, in from twelve to sixteen longitudinal series, appearing as though ranged between raised ridges, nine at the margins and eleven at the center of the branch in three mm. longitudinally; interspaces thin.

The erect form of growth and acute angle of bifurcation, thinner walls and narrower non-celluliferous margins distinguishes this species from *T. ramulosa.*

Position and locality: St. Louis group; Elizabethtown, Ky.

PTILOTRYPA Ulrich.

(For generic diagnosis see page 393.)

PTILOTRYPA OBLIQUATA Ulrich.

Pl. XXX, Fig. 1-1e.

Zoarium consisting of frondescent branches varying considerably in height, width and thickness; the extremes of thickness noticed are 1 and 6 mm, The material at hand, though abundant, is not sufficient to determine the nature of the basal attachment. My judgment, however, would say that the basal portion was in *Tæniodictya* and not jointed as in *Ptilodictya.* Surface smooth. Zoœcial tubes almost straight in their course from the median laminæ to the surface with which they form an angle of between 25° and 40°. Apertures lanceolate, rounded and with an elevated margin posteriorly, acute and drawn out trough-like at the upper end. At irregular intervals the surface presents spots where the apertures are more than usually drawn out; they have a striated appearance and simulate maculæ. In the spaces between these spots the apertures are ranged in vertical series, separated in this direction by an interspace equal or greater than their longitudinal diameter which is about 0.25 or 0.30 mm.; in the diagonal series they approximate quite closely,the slight peristomes being separated by only a narrow channel; measuring diagonally there are about seven in two mm. At the upper end of each zoœcium, or in the interspace above it, is found an accessory pore. An occasional complete diaphragm crossing at right angles is found in most of the zoœcial tubes. The walls of the tubes have a very curious structure as shown in longitudinal and transverse sections (fig. 1d and 1 e.).

This is the only species of the genus thus far described. The obliquity of the tubes at once distinguishes it from any Ptilodictyoid know to me. The associated *Pachydictya splendens* alone sometimes approaches it in that respect.

Position and locality: Cincinnati group, Wilmington, Ill.

.NTRAPORA Hall, 1881.

Trans. Albany Instit. vol. X, p. 157.

(For generic diagnosis see page 394.)

INTRAPORA COSCINIFORMIS Nicholson.

Pl. XLIII, fig. 6, 6*a*.

Ptilodictya cosciniformis Nich. 1875. Geol. Mag. n. s. vol. II, p. 35, Pl. II. fig. 2-2*b*.

Ptilodictya cosciniformis Nich. 1875. Rept. Pal. Ont. p. 80, Pl. II, fig. 2*a*, 2*b*.

Although differing considerably in its mode of growth from *I. puteolata* Hall, the type of the genus, thin sections as figured prove them to be congeneric. The zoarium resembles that of *Coscinium* Keyserling.*

Position and locality: Hamilton group; Arkona, Canada. It should be searched for in the Illinois and Iowa exposures of the formation.

STICTOPORELLA Ulrich, 1882.

(Jour. Cin. Soc. Nat. Hist. vol. V, p. 152.)

(For generic diagnosis see page 394.)

STICTOPORELLA BASALIS Ulrich.

Pl. LXXV, fig. 5-5*b*.

Zoarium attached to foreign bodies by a large spreading, thin, basal expansion, from which arise irregular inosculating

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*Since writing the above, Vol. 6, Pal. N. Y., has appeared. In this work Prof. Hall proposes a new genus, *Coscinella*, for a cribrose form which, if indeed it is not the same species, is at any rate congeneric with Nicholson's *P. cosciniformis*. I question very much whether *Coscinella* can stand as distinct from *Intrapora*. On the other hand, the relationship to *Coscinium* is remote.

bifoliate fronds, varying in width and height; thickness rarely exceeding 2 mm., generally much less. Surface smooth, with cell apertures sub-circular, varying but little in size, averaging 0.13 mm. in diameter, seven or eight in 2 mm., regularly arranged in the spaces between the maculæ, which usually are much the largest over the basal expansion. Immediately surrounding the zoœcia apertures there is a narrow, slightly elevated sloping space, which on the other side slopes again into the sub-angular mouths of a single or double series of small mesopores. The latter are aggregated at intervals of about 3 mm. into clusters varying much in size. Median lamina very flexuous, with difficulty distinguished from the long prostrate basal portion of the zoœcial tubes. These overlap each other for a considerable distance before they make an abrupt bend and proceed direct to the surface. Walls moderately thick in the vestibular, thin in the primitive region. Superior hemiseptum obsolete, inferior, sometimes quite pronounced. Diaphragms entirely wanting, even in the mesopores.

Position and locality: Keokuk group; Warsaw beds, Warsaw, Ill.

STICTOPORELLA? UNDULATA Ulrich.

Pl. LXIX, fig. 6-6*b*.

The specimens upon which this species is founded are two small, imperfect, undulating fronds, less than 2 cm. in height and width, and about 0.5 mm. in thickness. Surface nearly smooth, exhibiting a few inconspicuous elevations, the centers of which are occupied by zoœcia separated by slightly wider interspaces than usual. Zoœcia arranged in regular series varying in direction. Apertures almost circular, sub-equal, about 0.15 mm. in diameter, eight in 2 mm., with small mesopores placed at the angles of junction. Interspaces rather thin.

The smaller and more delicate frond, and much less numerous mesopores, distinguish this form from *S. basalis* of the Keokuk group.

Position and locality: Chester group, Litchfield, Ky.

FENESTELLA Lonsdale, 1839.

(Murchison's Silurian System, p. 677.)

(For generic diagnosis see page 395.)

Very much indeed might be written upon this remarkably prolific group of Bryozoa, but, as space is limited, I must refrain. A few remarks however seem to be called for.

In looking over the one hundred or more described species of *Fenestella**, we see that the original infundibuliform zoarium, which prevailed exclusively among the species of the Cincinnati and Clinton groups, gradually gave way in the Niagara and Lower Helderberg deposits until in the Upper Helderberg and Hamilton groups it is far less common than the flabellate zoarium, while in the Lower Carboniferous groups and Coal Measures the original form of growth is almost unknown. The number of the flabellate species is also so much greater that it is evident that the genus had not attained its most typical development before the beginning of the Upper Helderberg. The earliest infundibular species are really the ancestors of the whole family, and in the Niagara and Lower Helderberg groups several species show departures from the original simple forms along lines of variations which did not attain full development until well into Devonian times. Thus in *F. acmea* Hall, *F. thyene* Hall, and other species we see the progenitors of *Semicoscinium*. *Unitrypa* was developed from such forms as *F. quadrula* Hall, and *F. præcursor* Hall, while two- and three-ranged *Polyporæ* began early. No intermediate forms are as yet known showing the descent of *Isotrypa*, of which the Niagara *F.? ambigua* Hall, is already a fully developed species.

These facts are thrown out rather in the light of suggestions to students who are desirous of working out the life history of the family. My own investigations in this line have scarcely begun, yet the results have already proved most gratifying and sometimes surprising.

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* Many more have been described as *Fenestella* that belong to *Polypora*, *Semicoscinium*, *Unitrypa* and other genera of the family.

Fenestella vera Ulrich.

Pl. XLIV, figs. 1, 1*a*, and Pl. LIV, fig. 3.

Zoarium a somewhat undulating flabellate expansion; largest fragment seen over 6 cms. in length. Obverse with branches rather straight, slender, ridge-shaped, bifurcating at distant intervals, about 0.35 mm. in width, and twenty-four in 1 cm. Dissepiments short, sub-carinate, varying in width from about two-thirds to almost the width of the branches. Fenestrules elliptical or sub-quadrangular, about 0.5 by 0,2 mm.; fourteen in 1 cm. Carina prominent, not sharp, bearing small nodes about twice their diameter apart, and six or seven in 2 mm. Zoœcia in two ranges. Apertures small, circular, opening obliquely into the fenestrules, generally four to each fenestrule, and twenty-three in 5 mm. On the reverse the branches are usually zigzag, on the same level and scarcely stronger than the dissepiments, the fenestrules have a somewhat hexagonal shape, less marked in the older portion of the zoarium, and form quite regular diagonal series. Surface of both branches and dissepiments very minutely granulose.

This species was at first supposed to be identical with Prout's *F. nodosa*, but upon a careful comparison with his description, I find that the measurements do not agree. The flexuous character of the branches on the reverse is perhaps the principal peculiarlty, and serves to distinguish the species from several Devonian forms that approach it in other respects.

Position and locality: Hamilton group. Abundant at Buffalo, Iowa.

Fenestella filistriata Ulrich.

Pl. XLIX, fig. 2, 2a.

Zoarium a flabellate expansion, with the margins curved so as to give to the whole a semi-funnel shape. Base slender, solid, with root-like processes. Branches lax, rather slender, subcarinate, 0.35 to 0.5 mm. wide, and about four in 3 mm. Dissepiments slender, striated, varying in length. Fenestrules subquadrangular, much longer than wide, about six in the space of 1 cm. Carina rarely prominent, it and the sides of the branches covered with fine longitudinal striæ. Zoœcia in two ranges. Apertures circular, elevated, almost twice their diameter apart, six or seven to a fenestrule, thirteen or fourteen in 5 mm. On the reverse the branches are striated longitudinally as on the obverse.

This species is much more delicate than the *F. regalis* of the Keokuk group. *F. funicula* has a stronger keel, and no striæ upon the obverse.

Position and locality: Burlington limestone, Burlington, Iowa, and Montezuma, Pike Co., Ill.

FENESTELLA BURLINGTONENSIS Ulrich.

Pl. XLIX, fig. 1, 1a.

Zoarium a foliate expansion, with strong root-like processes extending from the sides near the base. Branches rather strong, a little irregular, from 0.3 to 0.5 mm. wide. Dissepiments short, rounded or subangular, depressed, from one-half to two-thirds the width of the branches. Fenestrules irregular in shape and size, varying from subquadrangular to narrow elliptical, averaging 0.7 by 0.4 mm., with eight to ten in 1 cm. Carina strong, moderately elevated and bearing a row of obscure nodes. Zoœcia in two ranges. Apertures circular, small, widely separated, about seventeen in 1 cm., and from three to five to each fenestrule. On the reverse the dissepiments are more slender and fenestrules more rectangular than on the obverse. On the branches are a few obscure nodes.

The Burlington Bryozoa are rarely good, and the examples of this *Fenestella* which I have seen are no exception to the rule. They show perhaps too great a variation to have all belonged to one species, yet as the state of preservation did not admit of nice discriminations, I thought it best to unite provisionally the forms comprised in the above description under one name. The example of which fig. 1a, represents a small portion has smaller and more crowded branches than usual. The species is related to *F. rudis* of the Keokuk group, but has smaller cell apertures and somewhat larger fenestrules.

Position and locality: Burlington limestone. Burlington, Ia.

FENESTELLA RUDIS Ulrich.

Pl. XLIX, fig. 3—3d.

Zoarium flabellate, usually forming but little undulated subcircular expansions, attaining a diameter of 7 cms. or more. Numerous root-like strong and smooth processes strengthen the small base from which the branches diverge. These are strong, moderately rigid, and bifurcate at intervals varying from 5 to 15 mm. On the obverse the branches are angular, the keel strong but not very prominent, and carries large elongated nodes about two to each fenestrule. The elevations of the nodes varies in different examples being very prominent in some and scarcely perceptible in others. Age and state of preservation largely account for the variation. The average width of the branches also varies from 0.28 to 0.33 mm. In all the average strength is somewhat greater near the base than at the outer margins; their number in a given space is, however, fairly constant, there being usually sixteen or seventeen in 1 cm. Fenestrules elongate elliptical, twice as long as wide, with ten and one-half in 1 cm. Dissepiments depressed, comparatively weak, rarely half as wide as the branches. Zoœcia in two alternating ranges, eighteen in 5 mm., three to each fenestrule, with rather large circular apertures, and slight peristome, separated by interspaces of nearly the same width as their diameter, which is about 0.12 mm. When well preserved the interspaces and dissepiments are faintly striated.

Certain shallow cavities on the sides of the keel (see fig. 3b,) may represent oœcia.

On the reverse the branches are strongly rounded, often irregularly tuberculose, at other times only thickened at their junction with the dissepiments. Between the nodes the surface is smooth or faintly striated.

This is one of the most persistent and characteristic species of the Keokuk group, and is easily distinguished from its associates by the robust and rather coarse aspect of its fronds. *F. burlingtonensis* is nearly allied, but has larger fenestrules. The common European *F. plebeia* McCoy is also closely related but differs in a like manner.

Position and locality: Keokuk limestone, Keokuk and Bentonsport, Iowa, Warsaw, Nauvoo, and other localities in Illinois. Also in the Warsaw beds, at Warsaw.

FENESTELLA LIMITARIS Ulrich.

Pl. XLIX, fig. 4, 4a.

Zoarium a convoluted foliar expansion, several cms. in width, consisting of rather strong, rounded, subequal, and flexuous rather than rigid branches; sixteen or seventeen in 1 cm. On the obverse side the branches vary in width from 0.25 mm. just above, to 0.5 just below a bifurcation, but the normal width is fairly constant at 0.35 to 0.4 mm. Median keel obsolete, or represented by a faint, somewhat flexuous, thread-like line, scarcely rising above the cell-aperture margins. Zoœcia in two alternating rows, seven to two fenestrules, fifteen in 5 mm., with rather large and more than usually direct, circular apertures, surrounded by a prominent peristome. Dissepiments depressed, narrowly rounded, thin, rarely half as thick as the branches. Fenestrules narrow, elongate sub-elliptical, indented by the projecting cell mouths, with an average of ten in 1 cm. On the reverse they appear wider and more regular, and may be said to be generally oblong quadrate in outline, with the length equal to about twice the width. Here also the branches are rather narrowly rounded, and more or less distinctly striated.

The very little developed median keel distinguishes this species from *F. rudis*, its nearest congener. At the same time it reminds us of species of *Polypora* like *P. biseriata*, but as the branches never carry more than two rows of cells it is evidently still within the limits of *Fenestella*.

Position and locality: Keokuk group. Rare at Bentonsport and Keokuk, Iowa.

FENESTELLA REGALIS Ulrich.

Pl. L, figs. 1, 1a, and Pl. LIV. fig. 5.

Zoarium flabellate, usually forming a flat, sub-circular expansion, 4 or 5 cms. in diameter. Branches very strong, rather flexuous, bifurcating in the lower and middle portions of the expansion at intervals of 4 to 8 mm.; number of branches in 1 cm., nine or ten; average width of same, about 0.7 mm., just before bifurcating it is 0.8 or 0.9 mm. and just above the division 0.5 or 0.6 mm. Dissepiments slender, less than half as wide as the branches, rounded or sub-carinate, Fenestrules large, of variable form, usually subangular and two or three times longer than wide; about four or five in 1 cm. Carina strong, rounded, bearing a row of small nodes about 0.8 mm. apart. Zoœcia in two alternating ranges, from seven to eleven in the length of a fenestrule, and fourteen in 5 mm. Apertures circular, about 0.16 mm. in diameter. In well preserved examples with a prominent peristome. In such the interspaces and carina are finely striate. On the reverse the branches are strongly convex and striated longitudinally. In tangential sections the solid substance on the sides of the branches is seen to be traversed transversely by very fine and crowded tubuli.

The very large size of the branches and fenestrules distinguish the species from all known to me. Indeed its branches with their two ranges of zoœcia are fully as large as those of *Fenestralia sancti-ludovici* Prout, in which there are four rows.

Position and locality: Keokuk group. King's Mt. Tunnel, Kentucky (On Cin. South. R. R.).

FENESTELLA COMPRESSA Ulrich.

Pl. L. Fig. 2a.

Zoarium a flat foliar expansion, the largest fragment seen being over 6 cm. long. It spreads unusually slow because of the long intervals between the bifurcations. The branches, of which there are fourteen or fifteen in 1 cm., are rigid (especially on the obverse), and compressed laterally, so that the zoœcial apertures look sidewise rather than upward. The width of the branches is nearly uniform, varying but little from 0.35 mm. On the obverse they are strongly keeled. The carina carries a series of small nodes which are nearly or quite as numerous as the zoœcia on either side. Zoœcia sixteen in 5 mm. four to each fenestrule, with small apertures and faint peristome. Dissepiments slender, sub-carinate, half as wide as the branches. Fenestrules sub-quadrate, appearing rectangular in specimens partially obscured by the shale; generally twice as long as wide, 8.5 in 1 cm. On the reverse the branches are rounded and distinctly striated longitudinally.

The compressed branches, large fenestrules, small and widely separated cell-apertures, and numerous nodes on the keel, are the distinctive features of this species. Its frond has a more delicate look than any of the associated forms.

Position and locality: Keokuk group. King's Mountain Tunnel, Ky. I have collected several fragments of this or a very closely allied species from the Chester group at Sloan's Valley, Ky.

FENESTELLA COMPRESSA var. NODODORSALIS Ulrich.

Pl. L, fig. 2.

This name is proposed, provisionally, for a form of which I have seen only one example. This is over 8 cm. in length by 4 cm. in its greatest width. It adheres tightly to a slab of limestone from King's Mountain, with the reverse, which is finely preserved, exposed. As it agrees fairly well in the strength of its branches, form and size of its fenestrules, with *F. compressa*, I at first supposed that it represented the reverse of that species. Having occasion to prepare some thin sections of the type specimens of *F. compressa*, I was surprised at seeing no indications of a tuberculated reverse. This discovery led to an examination of all the specimens I had referred to the species. The result was that the reverse of all the specimens, excepting the one in question, was found to be simply rounded and even. A careful comparison shows that beside the strong and irregular nodes, there are also slight differences in the measurements. Thus, while *F. compressa* has fourteen or fifteen branches and 8.5 fenestrules in 1 cm., this specimen has twelve or thirteen branches, and 7.5 to 8 fenestrules to that space. Under these circumstances it seems best to refer to it as above.

FENESTELLA MULTISPINOSA Ulrich.

Pl. L, Figs. 3-3e.

Zoarium a strongly undulating flabellate expansion. The largest example seen (it is nearly perfect) measures in different directions from the base from 5 to 7 cm. Strong root-like appendages spring from the free margins and from both faces of the basal portion. Branches rigid, except near the base, where frequent bifurcations make them appear flexuous. They are also slender, from 0.3 to 0.4 mm. wide, with twenty to twenty-one in 1 cm., but being well knit together the whole frond appears comparatively strong. On the obverse the keel is pronounced but never sharp, and bears, on an average, three small nodes to the fenestrule. Zoœcia in two ranges. Apertures small, sub-oval or slit-like, seemingly situated in a groove at the base of the keel, with the outer margin prominent, sometimes appearing almost spine-like; twenty-one in 5 mm., two or three in each fenestrule. Certain saucer shaped depressions which occasionally take the place of one of the zoœcia, may be of the nature of oœcia. Dissepiments half or less than half as wide as the branches, scarcely depressed, carinate. Fenestrules (beyond the basal parts) regular, elliptical or sub-quadrate, fourteen or fifteen in 1 cm. On the reverse near the outer margin, the branches are straight, and covered with granose longitudinal striæ; the dissepiments half as strong, and the fenestrules sub-quadrate, with the length nearly twice the width. Toward the base the branches and dissepiments, the latter particularly, are much thickened, so that the fenestrules gradually become round-oval. The granules are also larger and no longer arranged in longitudinal lines.

This fine species may be compared with *F. compressa* and *F. serratula*. The former differs in having much larger fenestrules and in wanting granules on the reverse. The latter in being more delicate and smaller in every feature.

Position and locality: Keokuk group. Bentonsport and Keokuk, Iowa, and King's Mountain, Ky.

Fenestella triserialis Ulrich.

Pl. L, figs. 4, 4*a*.

Zoarium a foliaceous expansion. Branches rigid, of moderate strength, 0.4 to 0.45 mm. wide, seventeen or eighteen in 1 cm.; rather flat on the poriferous side, which alone has been seen.

Dissepiments short, depressed, slender, less than half the width of the branches. Fenestrules 12.5 in 1 cm., each about 0.6 mm. long and 0.25 mm. wide; with the sides indented. Carina very small, with a row of closely set small nodes, and on each side a continuous or interrupted fine line. Zoœcia in two ranges. Apertures circular, with well developed peristome, comparatively large, closely arranged, their diameter or less apart, nineteen or twenty in 5 mm., and regularly three to each fenestrule. A very perfect fragment, obtained since the plates were lithographed, shows a peculiar feature not noticed at that time. At the same time it explains the small spots which are shown in sections between the cells. In this specimen a long tubular spine extends from the interspace between the apertures obliquely outward and upward. Being very delicate, these spines would readily give way to attrition, but, since I know of its existence, I can detect its base in the other specimens.

Perfect examples of this interesting species could not be confounded with any other known. In its ordinary state of preservation it resembles *F. multispinosa,* but differs in having longer fenestrules, larger branches and zoœcia apertures, and less angular obverse side to the branches. The last character and the large cell apertures distinguish it from *F. compressa.* That species also has larger fenestrules.

Position and locality: Keokuk group. Rare at King's Mountain, Ky.

FENESTELLA FUNICULA Ulrich.

Pl. LI, fig. 6.

Zoarium an irregular foliar expansion. Branches fourteen or fifteen in 1 cm., comparatively slender, about 0.4 mm. wide, at times a little flexuous, approaching and receding from one another without regularity. Bifurcations at variable though generally rather distant intervals. Dissepiments of unequal length; their width a little more or less than one-half that of the branches. Fenestrules variable in size and shape, from three to four or five times as long as wide, with about five in 10 mm. Carina strong, cord-like, carrying strong nodes about 0.7 mm. apart. Zoœcia in two alternating ranges. Apertures occupying a groove at the base of the carina, thirteen in 5 mm., usually sub-circular, with only the outer margin strongly elevated; often they appear slit-like, an appearance probably due to compression; from four to six or even more between succeeding dissepiments. Reverse not seen.

This species is less robust and more irregular than *F. regalis*. *F. filistriata* of the Burlington limestone, is more delicate and without the cord-like keel.

Position and locality: Keokuk group. Rare at Keokuk, Iowa.

FENESTELLA CINGULATA Ulrich.

Pl. LII, figs. 1-1*d*.

Zoarium a large and strong, flat, foliar expansion, the largest fragments at hand indicating a diameter of at least 8 cm. Branches strong, equal, about 0.5 mm. wide, rigid, bifurcating at long intervals; fifteen in 1 cm. Dissepiments strong, generally two thirds as wide as the branches, usually elevated node-like, a peculiarity particularly noticeable on weathered examples, giving them a very characteristic rough appearance, Fenestrules narrow, indented by the cell margins, about 0.8 mm. in length, and 0.15 to 0.25 mm. in width, eight or eight and one-half in 1 cm. Carina not well developed but bearing conspicuous nodes. Zoœcia in two alternating ranges. Apertures circular, 0.15 mm. in diameter, with strong peristome, about seven to two fenestrules and fifteen to sixteen in 5 mm. The opercular covers to the apertures are frequently preserved. Tangential sections taken close to the surface show the existence of a ring of exceedingly minute vertical pores around the zoœcia aperture. Under a high power these appear on the surface of the peristome as minute granules. On the reverse the branches are simply convex and narrower, the fenestrules larger and more regular in size and shape, while the dissepiments are about as wide as the branches, and on the same plane with them. Their surface is crowded with minute granules, which only on very young examples are arranged in longitudinal series. The specimen of which fig. 1*a* represents a portion, differs from all the others in having only thirteen or fourteen branches and seven fenestrules in 1 cm. In other respects it seems to agree very well with the typical examples above described.

This is the only species of the genus in which I have noticed anything like the ring of minute tubes around the zoœcial apertures. Perhaps it is a similar feature that Mr. Shrubsole figures for his Wenlock species, *F. reteporata.* In its proportions *F. cingulata* approaches *F. rudis,* but there are really so many differences between them that when once determined, even poorly preserved fragments are easily separated.

Position and locality: Keokuk group. Nauvoo, Ill., and Keokuk, Iowa.

FENESTELLA SERRATULA Ulrich.

Pl. L, fig. 5–5c.

This beautiful little species is known from the Keokuk, St. Louis and Chester groups and from the Warsaw beds. In each of these geological divisions the species has undergone some slight but recognizable changes, making it possible to distinguish them. Still they all agree so closely in their proportions and general appearance that I cannot for a moment question their specific identity.

Zoarium a foliar expansion, from 3 to 5 cms. in diameter. Branches rigid, small, 0.25 mm. wide, twenty-five or twenty-six in 1 cm., with a comparatively strong mesial carina, carrying small nodes, which give it on a side view the serrated appearance that has suggested the name. Nodes and zoœcia twenty-four to twenty-six in 5 mm., and three to each fenestrule. Apertures very small, 0.07 mm. in diameter with a prominent peristome when perfect. Dissepiments thin, not more than half as wide as the branches, depressed and carinate on the obverse side. Fenestrules narrow elliptical, seventeen to nineteen in one cm. Reverse of branches granulo-striate or nearly smooth (?), with an occasional long, barbed, spine-like appendage.

The Keokuk form is the smallest. Its branches bifurcate much more frequently than usual causing the frond to expand so rapidly that its edges meet or even overlap each other.

In the Warsaw beds specimens, which do not bifurcute as rapidly as in the Keokuk form, the reverse of the branches is finely granulo-striate when well preserved, and the fenestrules number eighteen or nineteen in 1 cm.; with twenty-five or twenty-six cell apertures in 5 mm.

In the Chester examples, which are rather large, strongly undulating expansions, the granules have not been observed on the longitudinal striæ, and the fenestrules number seventeen or eighteen in 1 cm.; the cell apertures twenty-four or twenty-five in 5 mm.

The St. Louis limestone form is intermediate in its characters between the Warsaw specimens on the one hand and those of the Chester on the other.

Though closely allied to *F. multispinosa*, its smaller proportions readily distinguishes it. In that species there are twenty-one zoœcia in 5 mm., while *F. serrata* has from twenty-four to twenty-six in that distance.

Position and locality: Keokuk group. Nauvoo, Ill.; Warsaw beds, Warsaw and Monroe Co., Ill.; St. Louis limestone localities in Caldwell, Lyon and Crittenden counties, Ky., occurring in the shaly and cherty beds of the group; Chester group, Sloan's Valley, Ky., where it is abundant.

FENESTELLA EXIGUA Ulrich.

Pl. LI, figs. 1–1a.

Zoarium a delicate foliar expansion. Branches slender, slightly flexuous, laterally compressed, of uniform width, about 0.27 mm. wide, with twenty or twenty-one in 1 cm. Dissepiments short, hour-glass shaped, one-half as thick as the branches. Fenestrules quite regular in size and shape, elliptical, about 0.6 by 0.2 mm., and thirteen to fourteen in 1 cm. Carina strong, elevated, with nodes about 0.4 mm. apart. Zoœcia in two ranges. Apertures occupying a slight groove at the base of the carina, circular, rather large, their diameter or less apart, twenty-two or twenty-three in 5 mm., so arranged that several times four to once three come in the space of a fenestrule. Ordinarily the peristome is wanting or faint, but on perfectly preserved portions it is remarkably prominent. On the reverse the branches and dissepiments are more nearly equal than on the obverse, their surface is strongly convex and smooth excepting opposite the ends of the dissepiments where a strong node is developed on the branch, The fenestrules are regularly elliptical.

In its proportions this species is larger than *F. serratula* and much smaller than *F. compressa.*

Position and locality: Warsaw beds. Monroe Co., Ill.

FENESTELLA TENAX Ulrich.

Pl. LI, figs. 2—2e.

Zoarium a very delicate but large foliar expansion, the largest fragment seen being 8 cm. high by 5 cm. wide. At the base and along the free lateral margins there are those peculiar barbed spine-like appendages. Branches slender, bifurcating at distant intervals, from 0.2 to 0.3 mm. (the latter just before bifurcation) wide. Dissepiments thin, rounded, one-fourth to one-third as large as the branches. Fenestrules long oval, 0.3 mm. long and 0.12 wide, indented once on each side when perfect. Carina strong, elevated, with declining sides, bearing traces of numerous small spines. Zoœcia in two ranges, with pustulose mouths. Apertures circular, small, more than their own diameter apart, usually situated, one opposite the end of each dissepiment and one opposite the middle of each fenestrule. On the reverse the branches show obscure striations and granulations, the dissepiments are thin, on a plane with the branches or a little depressed below them, wider and more rectangular than on the obverse.

Warsaw beds examples: branches in 1 cm. 28 to 30; fenestrules in 1 cm. 29 or 30; zoœcia in 5 mm. 28 or 29. Average Chester group example: branches in 1 cm. 28 to 30; fenestrules in 1 cm. 28 or 29; zoœcia in 5 mm. 27 or 28. Variety from the Chester group: branches in 1 cm. 28 or 29; fenestrules in 1 cm. 23; zoœcia in 5 mm. 24 or 25. The measurements of the branches and fenestrules in the last are taken from a large and fine example, that shows only the reverse. Fig. 2e, represents a part of one of its branches, and shows the relatively larger fenestrules. The cells were counted on a similar but more typical example.

In many respects this species resembles *F. serratula*. Both are abundant and almost constantly associated, showing that they are not local varities of one species. *F. tenax* has smaller and more numerous branches, as well as smaller fenestrules. Lying side by side, as it often happens, it needs but a glance to discriminate between them. Small fragments of both species resemble the fronds of associated species of *Archimedes* (particularly *A. proutana* and *A. distans*,) and it is only by becoming familiar with them through practice that they can be distinguished satisfactorily.

Position and locality: Warsaw beds, Warsaw, and Monroe Co., Ill. Chester group, Chester and Kaskaskia, Ill., and Sloan's Valley, Ky.

FENESTELLA CESTRIENSIS Ulrich.

Pl. LI, figs. 5—5b.

Zoarium an irregular foliar expansion, 5 or more cms. in length. Branches slender, rather rigid, 0.3 to 0.4 mm. wide, bifurcating at distant though variable intervals, seventeen to twenty in 1 cm., the average, however, being about nineteen. The two faces of the obverse side are rather flat and slope downward rapidly from the sharp carina. Dissepiments short, ridge-shaped, about one-half as wide as the branches. Fenestrules averaging ten in 1cm.; the extremes noticed being one more or less, varying from long sub-rectangular to long sub-oval, 0.8 by 0.3 mm. Carina scarcely elevated, when perfect, bearing a row of short spines, usually four in the length of a fenestrule. Zoœcia in two alternating ranges, twenty-one or twenty-two in 5 mm., four or five to each fenestrule. On the reverse the branches are narrowly rounded, distinctly striated in the younger or marginal portions of the expansion, with irregularly distributed nodes and no striations toward the basal or older parts. The fenestrules are more nearly rectangular than on the obverse.

This graceful species is one of the most characteristic Bryozoa of the Chester group. Although in no case very abundant it occurs at all the typical localities. In its measurements the the species agrees quite closely with *F. flexuosa*, yet the two are not likely to be confounded.

Position and locality: Chester group, Chester, Kaskaskia, near Anna, and other localities in the State of Illinois. Also at Sloan's Valley, and Litchfield, Ky.

FENESTELLA FLEXUOSA Ulrich.

Pl. LI, figs. 4—4c.

Zoarium a somewhat undulating foliaceous expansion that probably did not exceed 5 or 6 cms. in diameter. Branches slender, 0.3 to 0.35 mm. wide, rather irregularly flexuous, alternately bending toward and away from one another, eighteen to twenty in 1 cm. Dissepiments very short, connecting the branches where they approach each other nearest, their width about equal to that of the branches. Fenestrules long-oval, more or less pointed at the ends, somewhat variable as to size, about 0.8 by 0.2 mm., and nine or nine and one-half in 1 cm. Carina rather strong, moderately elevated, with generally three strong nodes or spines to the fenestrule. Zoœcia in two ranges about twenty-two in 5 mm. Apertures circular, their diameter or less apart, four or five to each fenestrule, with well developed peristome. On the reverse the branches are very finely granulo-striate or smooth, narrowly rounded or carinated, and on account of their zigzag direction, usually apper to inosculate. The fenestrules are a little longer than on the opposite side, elliptical, but somewhat variable both in shape and size.

This is a well marked form, and ought never to be confounded with any other Carboniferous species known.

Position and locality: Chester group. Not uncommon at Sloan's Valley, Ky.,? Chester, Ill.

FENESTELLA ELEVATIPORA Ulrich.

Pl. LI, Figs. 3–3a.

Zoarium a flat foliar expansion, of which only small fragments have been seen. Branches rigid, closely approximated, 0.25 to 0.3 mm. in width, twenty-five or twenty-six in 1 cm. Dissepiments short, slender, so much depressed that they are easily overlooked on examples adhering to the rock or shale. Fenestrules small, irregular in shape, about two and one-half times as long as wide, with about twenty-four in 1 cm. Obverse side of branches comparatively flat. Carina small, thread-like. Zoœcia in two ranges, twenty-six in 5 mm. Apertures circular, directed outward, pustuloid, the peristome being very prominent; generally two to each fenestrule. On the reverse the branches are rounded and occupied by from three to five thread-like longitudinal striæ, the fenestrules longer than on the obverse, and subquadrate in form.

The more strongly striated reverse, the less convex and somewhat wider obverse face of the branches, and their crowded appearance separate this species from its close relation, *F. tenax.* Other differences will be noticed on comparison.

Position and locality: Chester group, Chester, Ill., and Crittenden Co., Ky.

FENESTELLA DELICATULA Ulrich.

Pl. LII, Fig. 2.

Zoarium a very delicate, rapidly expanding, foliar expansion, not known to exceed 2 cm. in diameter. Branches very slender, about five in 5 mm., scarcely 0.3 mm. in width; strongly convex and finely granulose on the reverse, and ridge like on the obverse. Dissepiments long and very slender. Fenestrules subquadrangular, about 1.5 by 0.7 mm., and six or seven in 1 cm. Carina comparatively strong, rounded, with an occasional very small node. Zoœcia in two alternating ranges, about sixteen in 5 mm. Apertures circular, small, and widely separated; five or six to the fenestrule; peristomes prominent, especially upon the outer side where they encroach upon the fenestrules.

The specimens upon which this species is founded are very fragmentary, but as they are in a fine state of preservation and quite distinct from all the carboniferous species known to me, I have ventured to describe them as new.

Position and locality: Base of Coal Measures, Seville, Ill.

FENESTELLA MODESTA Ulrich.

Pl. LII, Fig. 3-3b.

Zoarium a small fan-shaped expansion; the largest specimen seen is 17 mm. in breadth, and somewhat less in height. Branches bifurcating frequently, slender, keeled, flexuous, 0.2 mm. in width, five or six in 3 mm., covered with fine longitudinal striations which continue from a branch across the dissepiments to the next branch. Dissepiments slender, rounded. Fenestrules subquadrangular, somewhat variable in size, about 0.7 by 0.3 mm., and six or seven in 5 mm. Carina rounded, not strongly elevated, with small nodes about 0.4 mm. apart. Zoœcia in two ranges, twenty or twenty-one in 5 mm. Apertures circular, surrounded by a thin peristome, almost twice their diameter apart, arranged several times three to once four in the space of a fenestrule. On the reverse the branches are covered with exceedingly fine, granulose, interrupted striations.

The specimens from Knox Co., Ill., occur as natural molds in a soft, fine grained, siliceous rock. The gutta-percha impressions which were prepared from them are, as usual, exceedingly perfect, showing clearly the minutest details of external structure and ornamentation. On the Seville examples the cell mouths, and, apparently, the keel as well, are a little more prominent than in those from Knox Co.

When compared with carboniferous species the distinctive features are the rapid expansion and small size of the frond, the comparatively large fenestrules, and the widely separated cell apertures. *F. delicatula* has larger fenestrules and five or six apertures instead of three or four to each. *F. mimica* is a more compact form and has stronger and rigid branches.

Position and locality: Coal Measures, Knox County and Seville, Ill.

Fenestella perminuta Ulrich.

Pl. LII, Fig. 4-4b.

Zoarium an exceedingly delicate small expansion, growing from a spreading foot stalk into a remote resemblance to *Ptilopora*. From both sides of the central stem two branches spring out at a rather acute angle. These are very slender, bifurcate at short intervals, and are 0.15 mm. in width. Dissepiments long, extremely slender, at first about equal in number to the bifurcations. Fenestrules of variable shape, averaging 0.5 by 0.3 mm. Carina very little developed, almost obsolete. Zoœcia apertures in two alternating rows, circular, prominent, projecting decidedly beyond the margin of the branch, more than twice their diameter apart, with twelve in 3 mm. On the reverse the branches are finely striated.

The extreme delicacy of the zoarium, in which the species is not equalled by any other known to me, and the projecting cell-apertures, are regarded as the principal peculiarities.

Position and locality: Coal Measures, Seville, Ill.

Fenestella wortheni Ulrich.

Pl. LII, Fig. 5-5a.

Zoarium a small, delicate, fan-shaped expansion. Branches comparatively strong, about twelve in 5 mm., each 0.25 mm. in width. Dissepiments about half as wide as the branches, rounded and widening considerably at the ends. Fenestrules sub-quadrangular, indented a little on each side, about 0.3 by 0.2 mm. and twelve in 5 mm. Carina very strong, sub-cylindrical or thread-like, about half as thick as the entire branch. Along the middle of the carina there is a row of small nodes, (their apical opening is better preserved than usual), distant from each other about 0.15 mm. Zoœcia in two ranges, twenty-four in 1 cm. Apertures small, circular, almost three times their diameter apart, situated one at the end of each dissepiment and one opposite the middle of each fenestrule. Peristome indistinct. Reverse not seen.

This interesting little species resembles *F. tenax* in many respects, yet has even a more delicate zoarium, and the cells more regularly arranged, while the strong cord-like keel gives it a peculiar appearance quite foreign to that one.

Position and locality: Base of Coal Measures, Seville, Ill.

FENESTELLA SEVILLENSIS Ulrich.

Pl. LII, Figs. 6-6a.

Zoarium a foliaceous expansion. Branches straight rather slender, rounded, 0.3 mm. wide, six in 3 mm. Dissepiments thin, about one-third as wide as the branches. Fenestrules quite regularly sub-quadrangular, 0.5 by 0.2 mm., eight in 5 mm., slightly indented at the middle by the encroaching zoœcia mouths. Carina obsolete, replaced by a fine sharply impressed line, bordered on each side by an intermittently stronger and fainter raised line. One or two thinner lines usually mark the longitudinal interspace between the cell apertures. Zoœcia in two ranges, sixteen or seventeen in 5 mm. Apertures comparatively large, circular, scarcely twice their diameter apart, usually situated one at each end of each dissepiment and one at a point midway between (*i. e.*, about two to each fenestrule). On the reverse the branches are rounded and have five or six fine parallel striæ. The fenestrules here are nearly rectangular.

The presence of an impressed line instead of a raised keel, and the interrupted striæ are regarded as the distinctive features.

Position and locality: Base of Coal Measures, Seville, Ill.

FENESTELLA MIMICA Ulrich.

Pl. LII, figs. 7, 7*a*.

Zoarium a small foliar expansion. Branches rather slender, rigid, about 0.25 mm. in width, and seven in 3 mm. Dissepiments short, about one-third as wide as the branches. Fenestrules sub-quadrangular, strongly concave at the sides, 0.35 by 0.2 mm. and seven in 3 mm. Carina a very fine and but little projecting line, bearing a row of small spines about 0.12 mm. apart. Zoœcia in two ranges, twenty-four in 5 mm. Apertures large, circular, with well developed peristome, slightly more than their diameter apart, generally two to each fenestrule, so arranged that one is opposite each dissepiment and one between. Opercular covers the same as those of the *F. sevillensis*, *F. wortheni*, *F. rudis*, and many other species.

This species is closely related to *F. tenax*, of the Warsaw and Chester beds, but is more delicate, has larger cell apertures and fenestrules and a smaller number of branches in a given space. *F. sevillensis* is larger, has longer fenestrules, fewer cells, and an impressed mesial line instead of a keel. *F. wortheni* differs in its remarkably developed keel.

Position and locality: Coal Measures. Seville, Ill.

FENESTELLA CONRADI Ulrich.

Pl. LII, figs. 8, 8*a*.

Zoarium a strongly undulated foliar expansion, several cm. in length. Branches strong, appearing very rough on their obverse side, about 0.4 mm. wide, with twenty-one or twenty-two in 1 cm. Dissepiments very short and broad. Fenestrules narrow, sub-elliptical, averaging 0.33 by 0.15 mm., sixteen or seventeen in one cm., arranged in diagonally intersecting series. Carina itself not much elevated, but the rather closely arranged compressed spines which it bears are very strong and exceptionally prominent when perfect. Their bases are often in contact when they form a sort of rough crest. Zoœcia in two ranges. Apertures circular, with slight peristome, arranged in a not very straight line, so that there are several times three to once two in the space of a fenestrule; twenty-three in 5 mm. On the reverse the branches and dissepiments are rounded, on the same plane and about equally thick, the former being thinner than on the obverse side. The fenestrules are almost perfectly circular. A small node, perforated at its summit, often occupies then center of the branch at a point midway between four adjacent fenestrules.

The circular fenestrules and other features of the reverse, and the strong spines on the keel, (they are more conspicuous than in fig. 8,) are relied upon in separating this species. The obverse brings *F. rudis* to mind, but that species is so much more robust that comparisons are unnecessary.

The name is given in honor of the discoverer, Prof. A. H. Conrad, of Shenandoah, Iowa.

Position and locality: Upper Coal Measures. Seven miles north of Red Oak, Iowa.

FENESTELLA INÆQUALIS Ulrich:

Pl. LII, figs. 9, *9a*.

Zoarium a strong, irregular, foliar expansion. Branches rather strong, not very straight, sixteen to eighteen in 1 cm.; variable in size on the reverse, where their width varies between 0.3 and 0.5 mm.; more equal on the obverse face, where their average width is about 0.4 mm. Dissepiments short, narrowly rounded, of variable thickness, generally less than half the width of the branches. Fenestrules sub-quadrangular or elliptical, unequal, averaging 0.8 by 0.3 mm., and nine in 1 cm. Carina strong but not much elevated, at the summit with a series of closely arranged small nodes, about ten in 1 mm. Zoœcia in two ranges, seventeen or eighteen in 5 mm. Apertures small, circular, surrounded by an abruptly elevated peristome which projects a little beyond the margin of the branch; a fraction less than four to a fenestrule. On the reverse the branches are marked with longitudinal, parallel, granulose striæ. The granules are distinct, and so closely arranged that their bases are in contact. When a little worn they disappear, and the surface is then either smooth or simply striated. The fenestrules have about the same form and are but little, if any, larger than on the obverse side.

None of the Coal Measure species known to me are as large as this one, nor is any one of them sufficiently like it to require close comparisons. Of Lower Carboniferous species, *F. cestriensis* and *F. compressa* are related, but not very closely.

Position and locality: Upper Coal Measures. Ball's Mill, Sangamon Co., Ill.

SEMICOSCINIUM Prout, 1859.

(Trans. St. Louis Acad. Sci. vol. 1, p. 443.)

(For generic diagnosis see page 395.)

On account of certain very unfortunate errors in Prout's original diagnosis of this genus, the name has not become current. His type specimen was, however, almost beyond question, a fragment of a large and easily recognized species which is common at the Falls of the Ohio. He mistook the obverse for the reverse side, and described the thin membrane which is often drawn over the summits of the high carinæ, as a longitudinally lined sole. The spaces between the branches and this membrane is filled with vesicular tissue. This he noticed and described, together with the true zoœcia, which he called "tortuous tubes," as a part of the "sole." The cells, he supposed, originated in the tortuous tubes and opened into the fenestrules. In short, his conception of *S. rhomboideum* was altogether incorrect.

The genus as now defined, departs from *Fenestella* in having the keel very much higher and expanded at the summit, and the branches zigzag on the reverse. The zoarium is always infundibuliform, with the inner side non-celluliferous.

Species of this genus can be recognized in the Niagara group, but it is not until we reach the Upper Helderberg rocks that they assume their most marked peculiarities and become abundant. Here we find nineteen species, the majority of which have been described by Prof. Hall under *Fenestella*. Seven more species are described by that author from the Hamilton group. Above this horizon the genus is not known.

SEMICOSCINIUM PLANODORSATUM Ulrich.

Pl. XLIV, figs. 3-3*b*.

Zoarium infundibuliform above the abruptly contracted base, with the free margins nearly flat, and somewhat undulated. Outer surface celluliferous, strongly ridged. Branches rather slender, sixteen or seventeen in 1 cm., 0.3 mm. wide just before a bifurcation, increasing gradually to 0.5 or 0.6 mm. Dissepiments very short, depressed, wider than the branches. Fenestrules very small, 0.25 by 1.2 mm., sub-oval, eleven or twelve in 1 cm. Carina about 0.4 mm. in height, thin at first, with the summit abruptly expanded and angular along the middle. The sides are wavy, the undulations corresponding closely both in number and position, with the zoœcia apertures beneath them. Zoœcia in two ranges, one on each side of the median keel. Apertures circular, opening directly upward, about 0.1 mm. in diameter, as much or a little more apart, eighteen in 5 mm.; with well developed peristome. On the reverse the fenestrules vary from quite regularly circular to broad oval, are 0.3 or 0.4 mm. in diameter, and much farther apart longitudinally than transversely. Surface of branches and dissepiments, when well preserved, with numerous small nodes, and varying between slightly convex or flat and appreciably concave. In the last case the fenestrules are encircled by an elevated rim.

This species is smaller in its proportions than either *Fenestella semirotunda* or *F. permarginata* Hall, from the same locality. Both of those species, which clearly belong to *Semicoscinium*, also have twenty cells to 5 mm., while in this there are only eighteen in that distance. Right here it may be well to remark that Hall's figures of the two species mentioned (Pal. N. Y. Vol. VI, Pl. 49) appear to be somewhat mixed.

Position and locality: Upper Helderberg group; Falls of the Ohio river.

SEMICOSCINIUM RHOMBICUM Ulrich.

Pl. XLIV, figs. 4—4a, and Pl. LIV, fig. 8.

Zoarium infundibuliform, large, undulated. Celluliferous face with the branches rather slender, more or less flexuous, alternately approaching and receding from each other, bifurcating at long intervals, very gradually increasing from 0.3 to 0.5 mm. between the bifurcations, seventeen or eighteen to 1 cm. Dissepiments very short, the branches appearing almost to inosculate, their width equal to or greater than the length of the fenestrule, varying from 0.6 to 1.0 mm. Fenestrules oval, rather unequal, but averaging about 0.6 by 0.2 mm., eight in 1 cm.; regularly alternating in the adjoining longitudinal series.

Carina strongly elevated, flexuous, but little thickened at the summit, frail, easily broken or worn away. Zoœcia in two ranges separated by a keel. Apertures circular, 0.09 mm. in diameter, their diameter or more apart, twenty-two in 5 mm. On the sides of the branches, but always opposite a dissepiment, are a number of large, irregularly distributed, shallow, thin rimmed sub-circular cells, about 0.3 in diameter, extending from the keel nearly across the dissepiment. Their number is variable but the average is about as shown in the figure. Similar structures are known to be possessed by several species of *Fenestella*, and unless they represent oœcia, their nature is not understood. As usual in species of this genus, near the base the carinæ are covered by a thin calcareous membrane, and the space under this and between the branches, is filled with loosely woven vesicular tissue. On the reverse the fenestrules are oval or sub-rhomboidal and arranged in regular diagonally intersecting series, eleven or twelve in 1 cm. The branches are thinner than the width of the fenestrule, carinate when well preserved, zigzag, and united by inosculation so as to form regular rhombs. The point of junction or intersection is more or less prominent.

This fine species is distinguished by the flexuous branches, and the large cells (? oœcia). *S. rhomboideum* Prout, has fifteen fenestrules where this has only twelve. They are besides not so regularly rhombic.

Position and locality: Hamilton group; Buffalo, Iowa.

Fenestrapora Hall, 1887, (1885?)

(Pal. N. Y. Vol. XVI, p. XXII.)

(For generic diagnosis see page 395.)

At first I was not inclined to admit this genus, but the subsequent finding of the dimorphic pores in three distinct species has convinced me of its claim to recognition. As regards the nature of these pores, I can only suggest a comparison with the "avicularian" cells of the *Chilostomata*.

FENESTRAPORA OCCIDENTALIS Ulrich.

Pl. XLIV, figs. 2—2a, and Pl. LIV, figs. 7—7e.

Zoarium infundibuliform, expanding rapidly, almost salver-shaped, but rounding gradually from the short stem into the horizontal portion. The free margins are flat or somewhat undulated. On the obverse or outer side, the branches appear rigid, moderately strong, and increase in width from 0.3 to 0.5 mm.; fourteen or fifteen in 1 cm. Dissepiments short, depressed, as wide or wider than the branches. Fenestrules rather regularly oval, averaging 0.7 by 0.38 mm. with eight in 1 cm. Carina about 0.4 mm. high, expanded at the summit, subangular or rounded above; both sides present a series of large pits or cells, separated by unequal intervals, but the average may be placed at two in the space of a mm. One of the cells also occurs on the top of the carina just beneath the bifurcations. Zoœcia in two ranges, one on each side of the median keel. Apertures circular, nearly direct, about 0.09 mm. in diameter, about twice their diameter apart, twenty in 5 mm.; and with a faintly elevated peristome.

On the reverse or inner side the fenestrules are broad oval, being wider then on the opposite face; rather irregularly arranged, varying from quincuncial to directly opposite. In the first order, which apparently prevails mainly near the center, the branches are zigzag, and somewhat depressed below the much stronger longitudinal interspaces that represent the dissepiments. In the other arrangement the branches are nearly or quite straight, and again much thinner than the rounded dissepiments, which continue across them obliquely or at right angles. The fenestrules are always wider than the branches. Large cells, of the same nature as those in the carinæ, with an average diameter of 0.14 mm., and direct or oblique apertures, are distributed over the surface of the branches and dissepiments. Their number is about equal to that of the fenestrules.

The internal structure is fully illustrated on Pl. LIV. When compared with *F. biperforata* Hall, from the same horizon in New York, we find that that species is more delicate, has the fenestrules smaller, the carina less pronounced, and the dimorphic pores on the summit instead of the sides, and much more numerous on the reverse. The branches are also more rigid. The form described by me as *Semicoscinium infraporosum* (Contr. Am. Pal. Vol. I, Pl. I, 1886) has all the characters of *Fenestrapora.* It is from the Upper Helderberg group, and differs from the two Hamilton species in its smaller size, strongly undulated frond, flattened and comparatively strong reverse aspect of its branches, and other points of minor importance.

Position and locality: Hamilton group; Buffalo, Iowa.

HEMITRYPA Phillips, 1841.

(Pal. Foss. of Cornwall, Devon. & Westsomerset, p. 27.)

(For generic diagnosis see page 396.)

For further discussions see chapter on classification, under the section treating of the FENESTELLIDÆ (page 349). Of the fourteen or more species known, one is from the Clinton, two from the Lower Helderberg, one or more from the Hamilton, four from the Keokuk and one or more from the Warsaw and St. Louis limestone.

HEMITRYPA TENERA Ulrich.

Pl. XLIV, fig. 7—7a, and Pl. LIV, fig. 10—10c.

Zoärium infundibuliform, only known from fragments. The obverse is a very delicate net-work in which the principal and secondary bars are indistinguishable, being equal in width and both zigzag: connected by lateral bars or scalæ of the same width, they form equal hexagonal interstices, arranged in very regular vertical and diagonally intersecting series, twelve in 3 mm. measuring along the rows. Their openings correspond in number to the zoœcia in the branches beneath them. Zoœcia observed only in thin sections. On the reverse the branches are straight or slightly zigzag, slender, thirteen or fourteen in 5 mm., rounded, somewhat variable in width, smooth when old, granular and striated longitudinally when young. Dissepiments short, in the middle about as wide as the branches, spreading at their junction with them; on some portions of the zoarium, opposite in adjoining rows, on others alternate. Fenestrules oval or subquadrate, about 0.5 by 0.2 mm., with fourteen in 1 cm.

The delicacy of the zoarium is its distinguishing feature.

Position and locality: Hamilton group, Rock Island, Illinois and Davenport and Buffalo, Iowa.

HEMITRYPA PROUTANA Ulrich.

Pl. LVII, fig. 1-1c.

Fenestella hemitrypa Prout, 1859. Trans. St. Louis Acad. Nat. Sci. Vol. I, p. 444, Pl. XVII, fig. 4-4a.

Zoarium a large flabellate or semi-infundibular expansion, more or less undulated toward the free margins. Obverse or inner side protected by a delicate net-work, formed by the union of longitudinal and transverse bars. The former consists of two kinds, a slightly stronger and more prominent set, which are developed directly over the center of the branches and united to them by short supporting pillars. These may be called the *principal* bars. A second set, which alternates with the principals and may be known as the *secondary* bars, are suspended over the space between the branches. The net-work is completed by a set of short transverse bars to which Prof. Hall applies the appropriate term "*scalæ*." According as the *scalæ* are developed oppositely or alternately in the adjoining longitudinal series, the principal and secondary bars are straight or zigzag, and the interstices, consequently, may be quadrate, pentagonal or hexagonal. In this species the last form is less the rule than usual. Measuring transversely, about twenty-six rows of interstices occur in 5 mm.; longitudinally about twenty-four. One to three small denticles sometimes project from the bars into the interstices. When this net-work has been denuded, which, on account of its delicacy, is often the case, the obverse face of the branches is seen to be ridge-shaped, from 0.2 to 0.32 mm. wide, and generally twenty-six in 1 cm. The median carina is neither sharp nor prominent, but carries small nodes (the broken pillars that support the superficial net-work) at intervals corresponding with the length of the zoœcia. Dissepiments very short, depressed, about half as wide as the branches. Fenestrules long-oval, small, about 0.3 by 0.1 mm., and eighteen or nineteen in 1 cm. Zoœcia in two ranges, twenty-three or twenty-four in 5 mm., with small, widely separated, circular apertures, and elevated peristome.

On the reverse the branches and dissepiments are on the same plane, usually ridge-shaped, forming quadrangular fenestrules of greater width than on the opposite face. On mature examples the branches are smooth or very finely granular. On young ones they are faintly striated.

This species is very common in the Warsaw beds, and occurs also, but rarely, in the Keokuk group. It is closely allied to the Keokuk *H. plumosa* (*Fenestella plumosa* Prout,) but differs in having nine or ten fenestrules in 5 mm., while that species has only 6.5 to 7.5 in the same space. There are most probably other differences, but the Keokuk species has not been observed in a sufficiently good state of preservation to permit of comparisons in the minute details of structure. As usual Prout's types of *H. plumosa* were denuded of the superficial net-work.

Below are described two varieties of *H. proutana*.

Position and locality: Rare in the Keokuk group at Warsaw, Ill., and Keokuk, Iowa; abundant in the Warsaw beds at Warsaw, and Monroe Co. in Illinois, and less common at Barrett's Station, St. Louis Co., Mo. The species occurs also in the St. Louis limestone of Caldwell Co., Ky.

HEMITRYPA PROUTANA var. VERMIFERA n. var.

Pl. LVII, Fig. 5-5a.

This variety is represented by a number of specimens which agree closely in their proportions with typical *H. proutana*. The following differences have been noticed. The branches and dissepiments on their reverse side are rounded instead of angular, and the fenestrules are more oval. The principal feature, however, are certain peculiar, tubular, vermiform bodies, which are irregularly distributed over and form part of the reverse face of the zoarium. They are about 2 mm. long and 0.5 mm. in diameter, lie more or less nearly parallel with the branches, and have a sub-circular opening at the distal extremity. At present I cannot give a satisfactory explanation of their nature.

Position and locality: Warsaw beds at Warsaw, Ill.

HEMITRYPA PROUTANA var. NODULOSA n. var.

Pl. LVII, Fig. 2-2c.

This form differs from the typical *H. proutana* in having the interstices of the superficial net-work decidedly rayed or floriform, the small denticles which project from the sides of the bars being more numerous and better developed. On the reverse the branches are somewhat thinner, rounded, and bear numerous small tubercles. The zoarium also does not attain the size of *H. proutana*, but in the other measurements the variety offers no striking difference.

Position and locality: Keokuk group, Keokuk and Bentonsport, Iowa, and Nauvoo, Ill.

HEMITRYPA NODOSA Ulrich.

Pl. LVII, Fig. 3.

The principal distinguishing feature of this species is the nodose enlargement on the reverse of the branches opposite their junction with the dissepiments. The branches are rounded, eleven or twelve in 5 mm., with an average width of 0.2 mm., increasing from 0.15 to 0.3 or 0.4 mm. before bifurcation, the dissepiments depressed, and less than half the width of the branches; the fenestrules oval or sub-quadrate, twice as long as wide, as wide as the branches, and seven or eight in 5 mm. The superficial net-work is very much like that of *H. proutana*, but the interstices are more nearly circular, about twenty in 5 mm., and the principal and secondary bars of about equal strength.

The strong nodes and more slender branches distinguishes the species from *H. plumosa* Prout sp. The specimen of which several branches are represented by fig. 3a, simulates this species in the nodose character of the branches, but in its measurements it is identical with young *H. aspera.* That it is only a peculiar example of that species is shown by the facts, that on other portions the nodes are on the dissepiments, and that the superficial net-work is spinous.

Position and locality: Keokuk group, Nauvoo, Ill., Keokuk and Bentonsport, Iowa. Not rare.

HEMITRYPA ASPERA Ulrich.

Pl. LVII, Figs. 4-4f and 3a.

Zoarium a flat, rapidly expanding, flabellate expansion, attaining a height of 3 or 4 cms., though usually not more than 2 or 3 cms. It grew upon some cylindrical body over which it spread to form a strong base. The example figured is stronger in this respect than usual, but a good idea of this portion of the zoarium can be gathered from it. The different sets of bars forming the superficial net-work are indistinguishable near the base, but farther up where the branches bifurcate less frequently, we find that the principal bars are elevated, generally opposite each second scala, into strong spines, that all the bars are thin and approximately of the same thickness, and that the interstices are rather irregular in shape and size, but, almost invariably, nineteen or twenty in 5 mm., measuring longitudinally.

On the reverse near the base the branches and dissepiments are rounded and thickened so as to be sub-equal and to make the fenestrules sub-circular; their surface here is either smooth or exhibits the remains of nodes. Farther up the fenestrules are quadrangular, about 0.4 by 0.25 mm., and eight or nine in 5 mm.; the dissepiments half the width of the branches, somewhat depressed at the ends, but with the center elevated into a prominent node. The branches are rigid, rounded and smooth, and increase from 0.2 to 0.4 or 0.5 mm. before bifurcating; about ten in 5 mm.; occasionally with a node that should have been developed on a dissepiment.

The nodes on the dissepiments and the strong spines on the superficial net-work distinguish this species from all others.

Position and locality: Keokuk group, Nauvoo, Ill., Keokuk and Bentonsport, Iowa.

HEMITRYPA PERSTRIATA Ulrich.

Pl. LVII, Figs. 6-6a.

Zoarium infundibuliform, strongly folded in the upper half, slowly expanding, 5 cms. or more in height, non-poriferous on the outer side. Superficial net-work with the interstices or openings circular, comparatively small, surrounded by a sloping area, generally hexagonal, sometimes pentagonal or quadrate in outline, about twenty in 5 mm.; the bars and scalæ sub-equal and sharply carinate. On the reverse the branches are rounded, with from three to six strong longitudinal striæ, and from one to three series of small but prominent spines, the central row being usually the most conspicuous. Average width of branches about 0.3 mm.; just before bifurcation at least 0.5 mm., with ten or eleven in 5 mm. Bifurcations remote. Dissepiments very short, much depressed, about half as wide as the branches. Fenestrules narrow, oblong oval, about 0.5 by 0.15 mm., and fourteen or fifteen in 1 cm.

The favose net-work is very much like that of *H. pateriformis*, but the reverse aspect of the two species is very dissimilar. The zoarium of that species is also smaller and plate-shaped rather than infundibuliform. The narrow fenestrules and strongly striated branches distinguish the species from *H. plumosa* Prout, and *H. proutana*.

Position and locality: Keokuk group, Bentonsport and Keokuk, Iowa.

HEMITRYPA PATERIFORMIS Ulrich.

Pl. LVII, Figs. 7-7c.

Zoarium patelliform, spreading rapidly from the short and strongly ridged footstalk. It is further supported by numerous root-like processes which extend downward from its under side near the base. On the obverse or upper face, the bars forming the superficial net work are carinated, the principal ones often a little the strongest, the interstices regularly circular, rather small, and alternating in adjoining rows, with about twenty-one in 5 mm. On the reverse the fenestrules are sub-circular near the base. Here the dissepiments are thickened so as to equal the branches and fenestrules in width. Toward the outer margin both the branches and dissepiments gradually become thinner, and the fenestrules wider, and oval or even sub-quadrate in form. The surface of the branches is rounded and, when well preserved, minutely granular. Between ten and eleven branches occur in 5 mm., and in the same space longitudinally nine or ten fenestrules.

The form of the zoarium, carinated bars of the superficial net-work, small interstices, and rounded branches separate this species from *H. proutana*. *H. perstriata* has very narrow fenestrules and strongly striated branches.

Position and locality: Keokuk group, Keokuk, Iowa.

ARCHIMEDES LeSueur (Owen), 1842.

(Amer. Jour. of Sci. Vol. 43, p. 19.)

(For generic diagnosis, see page 396.)

This remarkable genus of the FENESTELLIDÆ is so far known only from American Lower Carboniferous deposits. Here, however, the genus suddenly springs into prominence, first making its appearance with four species in the Keokuk group, (including the Warsaw beds*), two of them, the *A. grandis* Ulr., and *A. wortheni* Hall, being the largest yet discovered. In the St. Louis limestone, in which the Fenestellids are few and but illy preserved, no species of *Archimedes* has yet been met with, but in the overlying Chester group, the individuals and species again become numerous, being, perhaps, the most characteristic fossils of that division. Much diversity of opinion exists as to the possibility of separating the species of the genus by the characters of the axis, but no one, so far as I am aware, has heretofore given them much study, nor does it appear that any one has taken pains to collect much material, and I do not wonder then that so many palæontologists have expressed themselves

* These beds are usually classified with the St. Louis group, but judging mainly from the Bryoza, I should regard them as more intimately connected with the Keokuk group. That they are beds of passage between these two groups will scarcely admit of doubt.

as opposed to the specific divisions already established. A parallel case is found in the old practice of uniting all Monticuliporoids under the specific names of *Chætetes lycoperdon* and *Stenopora fibrosa*; other cases in the old methods of classifying the now well established species of *Fenestella* and *Pinnatopora* Vine (*Glauconome* of authors). This multiplication of species by the splitting up of old landmarks of palæontological nomenclature, being the result of special studies, is the strongest evidence of progression, showing at the same time how extremely limited our knowledge of nature really is.

Five valid species were proposed by Prof. Hall in 1857, (Proc. Am. Ass. Adv. Sci. Vol. 10), and in the following year (Geol. Rep. Iowa, 1858), he proposed the name *reversa* for sinistral examples of *A. wortheni.* To these the present work adds eleven more, of which only two are from the Keokuk group, the remainder being from the Chester. In proposing these species, I fully appreciate the difficulties that the student will have to meet in his attempts to identify them, yet, I can assure him, that they are by no means insurmountable, nor any greater than those which must be overcome in determining other groups of organisms. The first thing to be done is to grasp the essential characters. These, of course, are surest determined by their degree of prevalence and constancy, a test that can be applied only when the material at hand is plentiful. During the course of my work upon the genus I have had before me no less than 800 specimens, many of them nearly or quite perfect, this large amount of material being contained partly in the State Museum at Springfield, and partly in the extensive collections of Bryozoa belonging to Mr. J. M. Nickles and myself. Some of the species were represented by from 50 to considerably over a hundred examples, two by only one each, while of the others the numbers ranged from four to fifty. To determine the species the variations in the following characters must be learned: (1) the number of volutions made by the spiral axis in a given space; this is generally very constant; (2) the outline and relative diameter of the shaft and flange*; (3) when a portion or the

* The term "flange" is applied to the projecting portion of the axis that would be equivalent to the "thread" of a screw. By the "shaft" I mean the subcylindrical portion of the axis about which the "flange" revolves.

whole of the fenestrated expansion is preserved, observe the angle at which it diverges from the axial line; (4) the characters of the branches, fenestrules and zoœcia, and their number in a given space. The actual thickness of the shaft is available only to a limited extent, while the direction of the volution is only an individual peculiarity, both dextral and sinistral spirals occurring in, perhaps, all the species. The zoarium was free, and in some species at any rate, consisted of more than one spiral axis. In every instance where two spirals were preserved in connection they are turned in opposite directions. Two examples of this kind are represented on Pl. LXIII, figs. 9b and 14. The first shows on the left side how a new axis is formed. The outer margin of the perforated frond is at first slightly thickened, then gradually recurved upon its celluliferous side until a complete volution has been made. The succeeding volutions follow at regular intervals. The extreme constancy with which these volutions take place in, for instance, *A. communis* and *A. proutanus* is remarkable, and seems to me a severe rebuke for those palæontologists who decry what they are pleased to call a burdening of nomenclatnre by the foundation of species upon trivial individual peculiarities. Who is to say that these characters are trivial?*

Had I more space and plates at my disposal I would have described and illustrated the minute internal characters of the axis which in a number of species are quite distinctive. Magnified views of the fenestrated expansion, of which I give full and complete descriptions, would no doubt have materially aided in the determination of the forms, but they had also to be dispensed with. The following tabulated list of the species in which the more important features of each are noted, will, I hope, partially atone for the deficiencies.

* In the three years that have passed since writing the above, I have collected nearly a thousand additional specimens of *Archimedes*. In this large number every species here described, save *A. perminimus*, is represented, besides several species as yet undescribed. The study of these specimens has been most gratifying to me, since I was thereby afforded the very best demonstration of the specific validity of the characters upon which the species were founded. Nor did I experience even ordinary difficulty in discriminating between the species.

	Diameter of shaft in mms.	Number of volutions in 2 cms.	Angle of diverg'nce of fenestrated frond from the axial line.	Zoœcia in 5 mms.	Branches in 1 cm.	Fenestrules in 1 cm.	Number of examples.
A. negligens Ulr	0.7–1.5	3.7–4.6	80°	26	24–25	17	20
A. grandis Ulr.	5.5–6.3	1.6–2.0	60°	22	23–24	16	4
A. owenanus Hall.................	1.8–5.7	2–3	70°	?	22	13–14	11
A. wortheni Hall	5.1–10.0	2–2.4	65°	26	23–25	16	Abundant.
A. perminimus Ulr	0.25	4 in 5 mm.	?	?	?	?	1
A. compactus Ulr.................	1.0–2.7	9–11	75°	25	24	16	Abundant.
A. communis Ulr.................	1.0–2.0	7.3–8.	85–90°	20	24–25	15	"
A. intermedius Ulr	2.0–4.5	5.5–6.5	72°	22	22–23	16	"
A. swallovanus Hall	2.8–6.7	4.5–5.	85°	19–20	22	14	"
A. terebriformis Ulr..............	1.1–2.5	3.0–3.5	60–65°	?	?	?	30
A. invaginatus Ulr	2.3–4.5	3.7–5.	55–60°	26	23–25	16–17	31
A. proutanus Ulr.................	1.2–1.8	6–8.	65°	20–22	21	16–17	Abundant.
A. meekanus Hall................	0.7–1.6	4–5.	65°	25–26	23	20	25
A. distans Ulr.......................	0.8–1.4	3–3.5	45–50°	22	23	19–20	12
A. sublaxus Ulr....................	1.0–1.3	1.6–1.8	38–40°	26	22–23	16	2
A. laxus Hall........................	0.5–1.5	0.8	40–45°	21–22	20–21	13	25

ARCHIMEDES NEGLIGENS Ulrich.

Pl. LXIII, Fig. 7–7a.

Axis slender, lax, appearing delicate, faintly fusiform, at least ten cm. in length; volutions moderately irregular, varying in different examples from 3.6 to 4.5 in two cm. It is only in rare instances that there are more than four in that space. Shaft thin, slightly spiral. Fenestrated expansion from one to two cm. wide, making an angle of about 75° with the axial line. Branches slender, straight, 24 or 25 in one cm.; on the obverse with very faint carina separating the two rows of zoœcia, of which there are about 26 in five mm. Apertures small, with peristome. Fenestrules elliptical here, quadrangular on the reverse, a little longer than wide, about seven in one cm. Dissepiments about half as wide as the branches.

The axis of this form cannot be confounded with those of any other species known to me from this horizon. They resemble *A. terebriformis*, of the Chester group, but the shaft is not swollen below the flange, and the whole has a more delicate aspect.

Diam. of	shaft of	strongest	ex. 1.5	mm.;	No. of	vol. in	2 cm.,	4.
"	"	smallest	" 0.7	"	"	"	"	4.
"	"	average	" 1.0	"	"	"	"	3.8.
"	"	another	" 1.0	"	"	"	"	4.6.

Position and locality: Keokuk group, Bentonsport and Keokuk, Iowa.

ARCHIMEDES GRANDIS Ulrich.

Pl. LXIII, Fig. 10.

Axis very large and strong, the largest example seen, though incomplete at both extremities, being nearly eighteen cm. long, and making one volution to each cm. Of two other examples one makes eight the other nine turns in ten cm. The shaft is comparatively slender, and gradually spreads from the flattened top of a flange into the smooth under side of the succeeding flange, presenting on a large scale very nearly the appearance noticed in *A. invaginatus* of the Chester group. Fenestrated frond about five cm. wide, forming an angle of from 60° to 65°, with the axial line. Branches slender, 23 or 24 in one cm., slightly carinated on the obverse, and rounded on the reverse. Zoœcia about 22 in five mm., in two ranges. Fenestrules subquadrate, longer than wide, 16 in one cm. Dissepiments as strong as the branches.

Diameter of shaft 6 mm.; diameter of flange 2 cm.; number of volutions in 10 cm., 8, 9 or 10.

This fine species is related to both *A. owenanus* and *A. wortheni.* From the first the axis differs in having a wider flange and longer volutions, from the second in having the under side of the flange smooth, and in the outline of the shaft.

Position and locality: Keokuk group. All the specimens seen are from Jersey Co., Ill.

ARCHIMEDES OWENANUS Hall.

Pl. LXIII, Fig. 6–6c.

Archimedes owenana Hall, 1857. Proc. Amer. Ass. Ad. Sci., vol. 10, p. 178.

Axis probably very long, sometimes slender, at other times very strong; volutions disproportionately rapid at the proximal end, but soon they become longer; generally 2.5 occur in two cm., more rarely three, and occasionally only two. The shaft varies considerably in strength in different examples. Just above the flattened top of the flange it is sub-cylindrical, spreading a little in young examples toward the base of the succeeding flange, which bends abruptly outward, the junction between the two being marked by a more or less defined sulcus. Fenestrated expansion delicate, several cm. wide, leaving the axial line at an angle of about 70°. Reverse only seen. Branches narrowly rounded, 22 in 1 cm. Fenestrules oblong quadrate or elliptical, as wide as the branches, the length equal to one and a half times the width, with 13 or 14 in 1 cm. Dissepiments as strong as the branches.

Diam. of	shaft	of	strongest ex.,	5.7 mm.;	No. of	vol. in	2 cm.,	2.3.
"	"	"	smallest "	1.8 mm.;	"	"	"	2.7.
"	"	"	average "	2.9 mm.;	"	"	"	2.2.

The above description refers to the form usually identified with Hall's *A. owenanus.* The very incomplete original description contains nothing that does not agree with it. The position of the species is somewhat intermediate between *A. wor-*

theni Hall, and *A. terebriformis* Ulr., but is not near enough to either to require detailed comparisons.

Position and locality: Keokuk group, Keokuk, Iowa, Appanoose (Hall), and three miles northeast of Quincy, Ill.

ARCHIMEDES WORTHENI Hall.

Pl. LXIII, Fig. 8-8a.

Archimedes wortheni Hall, 1857. Proc. Amer. Ass. Ad. Sci., vol. 10, p. 178.

Archimedes wortheni Hall, 1858. Pal. Iowa, p. 651, Pl. XXII, fig. 3, 4a, 4b, 5a, 5b.

Archimedes reversa Hall, 1858. Ibid. p. 652, Pl. XXII, fig. 2.

Axis large, sub-fusiform, sometimes attaining a length of thirty cm. or more. Volutions regular, dextral and sinistral, varying in different examples from 5 to 6 in 5 cm. Shaft very short, comparatively small, abruptly spreading into the wide flange, the junction between them sharply defined. Upper end of flange flat or slightly concave; lower side usually a very little convex, and uneven, frequently with rather regular vertical depressions. Fenestrated expansion as much as six cm. wide, diverging from the axial line at an angle of 65°. On the obverse the branches are rigid and closely approximated, the fenestrules appearing very narrow. Separating the two rows of zoœcia there is a strong carina, carrying a series of compressed spines. Zoœcia about twenty-six in 5 mm., with small, prominently elevated apertures, very regularly arranged. On the reverse the branches are more slender, with from 23 to 25 in 1 cm.; the fenestrules are sub-oval, quite as wide as the branches, about once and a half their width in length, and 16 in one cm.; and the dissepiments generally a little stronger than the branches.

Diam. of shaft,		largest ex.	10.0;	No. vol. 5 cm.,			5.7;	diam. fl'ge,		28.
"	"	smallest "	5.1;	"	"	"	6.0;	"	"	15.
"	"	average "	7.2;	"	"	"	5.4;	"	"	20.

At Bentonsport, Iowa, there occurs what may be a small variety of this species. The length of the axis, as is shown by a nearly complete example, was not much more than 9 cm. There are eight volutions in 5 cm. Another example has only seven in that distance.

Hall describes *A. wortheni*, as having occasionally three rows of apertures below a bifurcation, and sometimes with zoœcia on the dissepiments. None of the numerous examples before me exhibit anything of the kind, and I do not doubt that both assertions are based upon defective observation.

Position and locality: Warsaw beds.

This is one of the most abundant and characteristic fossils of this horizon.

ARCHIMEDES PERMINIMUS Ulrich.

Pl. LXIII, Fig. 13 and 11, pars.

Of this species the example figured is the only one seen. Its axis is, however, so minute in its proportions that I cannot hesitate in pronouncing it distinct from all the other species known to me. In the form and construction the axis reminds us a little of the much larger species *A. terebriformis*, and it might be urged that *A. perminimus* is only the terminal or young condition of that species. But such an explanation would not occur to any one who has devoted only a moderate amount of time to the study of these peculiar Bryozoa. The number of volutions in a given space is approximately the same throughout the length of the spiral axis.

In the specimen under consideration there are four volutions in 5 mm. The shaft of the axis at its thickest part is only 0.25 mm. in diameter. The fenestrated expansion must have been very narrow. It is not preserved so as to enable me to give measurements of its minute features. The branches seen bifurcate at each dissepiment, and are about as wide as the fenestrules. The latter are elliptical, with a length equalling about twice the width of a branch.

Position and locality: Chester group, Chester, Ill.

ARCHIMEDES COMPACTUS Ulrich.

Pl. LXIII, Figs. 2-2e (?2c).

Axis small, sub-fusiform, not over 6 cm. in length, usually about 3.5 to 4.0 cm.; volutions varying from 9 to 11 in two cm.; shaft comparatively strong, nearly regularly concave on each side. Fenestrated expansion less than one cm. wide, forming an angle of 75° with the axial line. Branches slender, about as wide on the reverse as the fenestrules, 24 in one cm. Fenestrules once and a half as long as wide, oval or sub-quadrate, about 16 in one cm. Dissepiments rather thick. Obverse not observed. As determined by thin sections, there are about 25 zoœcia on each side of a branch in five mm.

The section represented by fig. 2c most probably does not belong to this species. It had a much stronger shaft, while the angle of the fenestrated expansion, as well as the outline is different. In these features it is exactly like the *A. intermedius.*

Thick. of shaft of			strongest ex.	2.7 mm.;	No. of vol. in 2 cm.,			9.
"	"	"	smallest	" 1.0	"	"	"	" 11.
"	"	"	average	" 2.0	"	"	"	" 10.

Position and locality: Chester group, Sloan's Valley, Ky., and other localities.

ARCHIMEDES COMMUNIS Ulrich.

Pl. LXIII, fig. 1-1*d*.

Axis slender, over twelve cm. in length, approximately of the same diameter throughout; volutions very regular, 7 or 8 in 2 cm.; shaft moderately strong, rather deeply and regularly concave on each side, so that it is difficult to distinguish the distal from the proximal extremity. Fenestrated expansion nearly always broken away, apparently not over one cm. in width, forming an angle of from 85 to 90 degrees, with the axial line. Branches rounded on the obverse, without a keel, 24 or 25 in one cm.; the zoœcia about twenty on each side in five mm., with small apertures and elevated peristome, separated by an interspace equal to once and a half their diameter. Fenestrules elliptical, nearly twice as long as wide, about 15 in one cm. Dissepiments thin.

Thick. of shaft of			strongest ex.,	2 mm.;	No. of vol. in 2 cm.,			8.
"	"	"	smallers	" 1	"	"	"	" 7½.
"	"	"	average	" 1.3	"	"	"	" 8.

The smaller axis, more regular and numerous volutions distinguish this species from *A. swallovanus* Hall. In *A. intermedius* there are about six volutions in two cm., and the fenestrated expansion forms an angle of 72° with the axial line.

Position and locality: Chester group. This is the most common as well as the most constant species of the genus. It occurs at most localities in the group, but is especially abundant at Sloan's Valley, Pulaski Co., Ky.

ARCHIMEDES INTERMEDIUS Ulrich.

Pl. LXIII, fig. 2*c*.

This form, which is also rather abundant, closely resembles both *A. communis* Ulr. and *A. swallovanus* Hall. It differs from the former in having from 5¾ to 6½ volutions in two cm., and in having a stronger axis. The angle formed by the fenestrated expansion is also smaller, being about 72 degrees, while in *A. communis* it is not less than 85 degrees. The last comparison holds good also for *A. swallovanus*. The axis of Hall's species makes from 4¼ to 5 volutions in two cm., and is generally also much stronger.

The Kentucky examples usually make one-half a volution more in two cm. than the Illinois specimens. The section figured was taken from an example from Chester, Ill., which had 6½ volutions in that distance, and is an exception to the rule.

Thick. of shaft of strongest ex., 4.5 mm.; No. of vol. in 2 cm., 6.
" " " smallest " 2.0 " " " " 5¾.
" " " average " 3.0 " " " " 6.

Position and locality: Chester group. Chester, Ill., and Sloan's Valley, Ky., and other localities. Common.

ARCHIMEDES SWALLOVANUS Hall.

Pl. LXIII, fig. 12-12*d*.

Archimedes swallovana Hall, 1857. Proc. Amer. Asso. Ad. Sci. vol. 10, p. 178.

Axis rather strong, of considerable length, approximately of the same diameter throughout (*i. e.* not appreciably fusiform); volutions regular, 4½ to 5 in two cm.; shaft strong but deeply concave, generally forming a regular curve, sometimes a little straightened above, or again quite straight at the sides (see fig. 12*a*). Fenestrated expansion of unknown width, forming an angle of about 85° with the axial line. Branches 22 in one cm., with a scarcely perceptible simple keel, and two ranges of zoœcia; in each 19 or 20 occur in five mm. Fenestrules elliptical, twice as long as wide, about 14 in one cm.

The smaller number of volutions, and the larger and stronger axis, distinguish this species from *A. communis* and *intermedius*.

It has not been found in the Chester group localities of Kentucky, where both of these species are abundant.

Diam. of shaft of	strongest ex.	6.7 mm.;	No. of vol. in 2 cm.,	5.
" "	another "	5.0 "	" " "	4½.
" "	smallest "	2.8 "	" " "	5.
" "	average "	4.0 "	" " "	5.

Position and locality: Chester group, at Chester and other localities in Illinois.

Archimedes terebriformis Ulrich.

Pl. LXIII, figs. 5–5*c*.

Axis rather slender, just a little fusiform, the largest specimen seen, which appears to be almost complete, is ten cm. long; volutions quite regular, varying in different examples from 3 to 4.2 in two cm.; shaft comparatively thin, distinctly spiral, thickened just below the spiral flange, the thickening best shown in medium sized specimens. Fenestrated expansion of unknown dimensions, forming an angle of from 60 to 65° with the axial line.

This form is readily distinguished from all the associated species by the spiral form of the shaft, and the swelling just beneath the flange. In other respects it compares closely with *A. negligens*, from the Keokuk group. The collection before me contains eight axes of what is probably a variety of this species. They lack the swelling below the flange, and have constantly 4.8 to 5 volutions in two cm. So far as observed they do not differ in any other respect from the typical specimens.

Diam. of shaft of	strongest ex.	2.5 mm.;	No. of vol. in 2 cm.,	3.1.
" "	smallest "	1.1 "	" " "	3.
" "	average "	2.0 "	" " "	3.

Position and locality: Chester group, Chester, Illinois, and rarely at Sloan's Valley and Grayson Springs, in Kentucky.

Archimedes invaginatus Ulrich.

Pl. LXIII, figs. 11*a*, 11*c*.

Axis rather strong, usually a little curved, over ten cm. long when complete, diminishing very gradually in strength toward each extremity; volutions regular, varying in different examples from 3.7 to 5 in two cm.; shaft comparatively slender just above the flange. The appearance of a series of invaginated oblique cones is more striking in this species than in any other. Fenestrated expansion two cm. or less in width, forming an angle of from 55 to 60° with the axial line. On the reverse the branches are narrowly rounded, from 23 to 25 in one cm., near the axis as wide as the fenestrules, becoming narrowed and somewhat zigzag toward the outer margin; fenestrules subquadrate, sometimes perceptibly pentagonal or hexagonal; 16 or 17 in one cm.; dissepiments nearly as strong as the branches. On the obverse the branches are usually without a keel, but a few spines may be detected. Zoœcia in two ranges, about 26 in five mm., with small aperture and peristome. On this side the fenestrules are narrower and elliptical.

Diam.	of shaft	of strongest	ex.	4.5 mm.;	No.	of vol.	in 2 cm.,	4.2.
"	"	smallest	"	2.3	"	"	"	4.5.
"	"	average	"	3.1	"	"	"	4.0.

The larger size, less numerous volutions, and the comparatively greater extent of the flange, as well as the absence of a spiniform keel and the smaller zoœcia, distinguish this species from *A. proutanus*, to which it is closely related. *A. intermedius* Ulrich, might be confounded with it, but a careful comparison will show among other differences, that while in that form the frond diverges from the axial line at an angle of about 72°, it takes place in this species at an angle of only 55 to 60°

Position and locality: Chester group, Chester, Ill.

ARCHIMEDES PROUTANUS Ulrich.

Pl. LXIII, figs. 3–3d, and 11, 11b.

Axis slender, as usual both sinistral and dextral, very gradually diminishing toward each extremity, appearing generally as of uniform size throughout. The longest specimen seen is of the average thickness, nearly complete, and ten cm. long. Volutions very regular, but varying in different examples of the typical form from 6 to 8 in two cm. Six examples before me belong apparently to a variety of the species. Two of these are represented by figures 11 and 11b. These differ from the typical form principally in being stronger and in having from 4.5 to 5.5

volutions in 2 cm. Shaft rather thin just above a flange, then gradually thickening and slightly curved outward to the margin of the succeeding flange. The under side of the flange is distinctly marked by the branches in the typical form, but much less distinctly in the variety mentioned. Fenestrated expansion usually not over one cm. wide, forming an angle of about 65° with the axial line. Branches about 21 in one cm., rounded on the reverse, with a moderate keel on the obverse, separating two rows of small scarcely elevated zoœcia apertures, of which from 20 to 22 occur in five mm. Keel with sharp spines three or four to each fenestrule. Fenestrules subquadrate, a little longer than wide, 16 or 17 in one cm. Dissepiments thin, scarcely half the thickness of the branches. In the large variety the fenestrules are somewhat longer, there being only about 15 in one cm.

Diam.	of shaft of	strongest	ex. 1.8	mm.,	No.	of vol.	in 2 cm.,	7.0.
"	"	smallest	" 1.2	"	"	"	"	7.2.
"	"	average	" 1.5	"	"	"	"	6.7.
"	"	av. large var.	2.5	"	"	"	"	5.0.

Although quite distinct and nearly as abundant, it requires care to distinguish this species from *A. communis*. These two species agree closely in the number of volutions and size of the axis. However, with a little experience the student will soon learn to detect their individual peculiarities at a glance. Thus in *A. proutanus* the flange is directed toward the distal extremity and furrowed on the lower side, while in *A. communis* the flange and fenestrated expansion extends out from the shaft at nearly a right angle. The form mentioned as a large variety may prove a distinct species. The specimens approach *A. invaginatus* in form and were at first supposed to belong to that species, but as the characters of the fenestrated expansion agree more closely with typical *A. proutanus* than *A. invaginatus*, I have thought it best to refer them, provisionally, as above.

Position and locality: Common at Sloan's Valley, Ky. It also occurs at Chester, Ill., and other localities in the State.

ARCHIMEDES MEEKANUS Hall.

Pl. LXIII, fig. 4.

Archimedes meekana Hall, 1857. Proc. Amer. Ass. Ad. Sci. Vol. 10, p. 178.

Axis slender, probably not exceeding seven cm. in length; surface minutely granulose; volutions 4 to 5 in two cm., shaft thin, faintly spiral, and spreading gradually into the flange, the lower side of which is generally furrowed (*i. e.* showing the base of the branches.) Fenestrated expansion of unknown width, diverging from the axial line at an angle of 65°. Branches rounded on the reverse, wider and faintly carinate on the obverse, the carina with closely crowded small spines. Zoœcia in two ranges, 25 or 26 in five mm., with very small elevated apertures. Fenestrules subquadrate on reverse, slightly longer than wide, about 20 in one cm. Dissepiments two-thirds as wide as the branches and even with them.

Diam. of shaft of		strongest ex.	1.6 mm.;	No. of	vol. in	2 cm.,		4.9.
"	"	smallest	" 0.6	"	"	"	"	5.0.
"	"	average	" 1.1	"	"	"	"	4.3.
"	"	another	" 1.0	"	"	"	"	4.0.

In its general appearance the axis of this species resembles that of *A. proutanus* Ulr., but differs in being more loosely wound. The zoœcia are considerably smaller, and the fenestrules and branches more numerous in a given place.

Position and locality: Chester group; not uncommon at Chester, Ill. Rare at Sloan's Valley and Grayson Springs, Ky.

ARCHIMEDES DISTANS Ulrich.

Pl. LXIII, fig. 9–9b.

Axis very slender and delicate, probably not exceeding eight cm. in length; volutions 3 to 3.5 in two cm.; shaft delicate, sub-spiral, spreading gradually into the flange, the lower side of which is, particularly in young examples, strongly furrowed vertically. Perforated frond from 1 to 4 cm. wide, diverging from the axial line at an angle of from 45 to 50 degrees. On the reverse the branches are rounded, about 23 in one cm., the fenestrules oblong quadrate, being about as wide as the branches and one-half of the width longer than wide, with 19 or 20 in one cm.; the dissepiments one-half as wide as the branches and nearly on a level with them. On the obverse the dissepiments and branches are carinate, the keel with small spines corresponding in number with the zoœcia, of which there are about 22 in five mm. Apertures of moderate size, with slight peristome, usually two, sometimes three to each fenestrule.

Diam. of shaft of strongest ex.,	1.4 mm.;	No. of vol. in 2 cm.,	3.5.
" " " smallest	"	0.8	" " " "	3.5.
" " " average	"	1.1	" " " "	3.3.

This species differs from *A. meekanus* Hall, in the longer volutions, larger zoœcia, and smaller angle of divergence of the fenestrated frond from the axial line.

Position and locality: Chester group. Not uncommon at Chester. Ill. I have also seen several examples from Sloan's Valley, Pulaski Co., Ky.

ARCHIMEDES SUBLAXUS Ulrich.

Pl. LXIII, fig. 14.

Of this species the specimen figured is the only one seen. It consists of two axes, one sinistral the other dextral, which obviously formed part of a single zoarium. The volutions are completed at intervals of 11 or 12 mm., the shaft slender and more or less spiral, from 1 to 1.3 mm. thick, spreading slowly upward into the small flange. Fenestrated expansion 1.5 cm. or less in width, diverging from the axial line at an angle of 38° to 40°. On the reverse the branches, of which there are 22 or 23 in one cm., and dissepiments are rounded, the latter two-thirds as thick as the former; the fenestrules a little longer than wide, as wide as the branches, of subquadrangular form, with about 16 in one cm. On the obverse the fenestrules are a little narrower, and the branches proportionately wider, with an inconspicuous, faintly spinous keel. Zoœcia in two ranges, with small apertures and slightly elevated peristome; about 26 in 5 mm.

The spiral axis of this species is more loosely enrolled and the shaft thinner than in any other of the genus excepting *A. laxus* Hall. In other respects it resembles the *A. owenanus* Hall, of the Keokuk limestone.

Position and locality: Chester group, Chester, Ill.

ARCHIMEDES LAXUS Hall.

Pl. LXIII, fig. 15-15a.

Archimedes laxa Hall, 1857. Proc. Amer. Ass. Ad. Sci. Vol. 10, p. 178.

Helicopora archimediformis Claypole, 1883. Quar. Jour. Geol. Soc. Vol. 39, p. 34, Pl. IV, fig. 3,4.

Axis very loosely enrolled, consisting of scarcely more than the thickened edge of the spiral frond; completing a volution at intervals of 2.5 cm. or more. Number of volutions probably not more than four. Fenestrated expansion diverging from the axial line at an acute angle, wide, the greatest width observed 5.5 cm., slightly decumbent toward the free margin. On the reverse the branches are narrowly rounded, becoming zigzag and thinner as they near the outer margin; 20 or 21 in one cm. Fenestrules oblong quadrate, or somewhat hexagonal, as wide or wider than the branches, with a length equal to nearly twice the width; about 13 in one cm. Dissepiments usually as strong or stronger than the branches, and sometimes more prominent. On the obverse the fenestrules are narrow, elliptical, the branches stronger and rigid, subangular, but without a keel. Zoœcia with rather small circular apertures more than their diameter apart, and very slight peristome, in two ranges excepting just below a bifurcation where some of the branches exhibit three rows; 21 or 22 in five mm.

As above cited, Prof. Claypole referred a specimen of this species to his new genus *Helicopora*. While agreeing that *A. laxus* closely approaches his genus, I am still indisposed to accept his arrangement, since it scarcely admits of question that the form is nothing more than a loosely coiled *Archimedes*. The Silurian type of his genus (*H. latispiralis*) does not appear to be so.

Position and locality: Chester group. Fragments are not uncommon at Chester, Illinois, and Litchfield, Ky.

LYROPORA Hall, 1857.

(Proc. Amer. Ass. Ad. Sci., vol. 10, p. 179.)

(For generic diagnosis see page 396.)

This genus, although presenting but few characters to distinguish it from either *Fenestella* or *Polypora*, is nevertheless a very convenient and natural group of Lower Carboniferous

Bryozoa. The relation to *Polypora* is in every way equivalent to that between *Archimedes* and *Fenestella*, the only difference being that while in *Archimedes* the stony support forms spiral volutions, in *Lyropora* it is V- or U-shaped. The form and other peculiarities of the support are quite constant for each species, and when this portion of the zoarium happens to be similar in two species, as for instance in *L. quincuncialis* Hall, and *L. ranosculum* Ulr., and *L. subquadrans* Hall, and *L. divergens* Ulr., marked differences are found in the structure of the net-work. This is more or less different in all the species, and I have found it possible to determine with certainty the specific relations of the merest fragments.

Six species, and possibly two more, beside one variety, are known to possess the characteristic support of the genus. With the exception of *L. retrorsa* M. & W., a rather rare species in the Burlington limestone, all are from the Chester group.

Lyropora ranosculum Ulrich.

Pl. LVIII, Fig. 1-1c.

Zoarium large, free, a foliate expansion spread between the recurved ends of a strong support. Support parabolic, the arms diverging at a variable degree, subcircular or oval in cross section, consisting of exceedingly thin, transversely grano-striate concentric layers of sclerenchyma, which are successively deposited upon the lateral margins of the strongly convex fenestrated expansion At the base of the support there is commonly an obtuse knob-like thickening. Fenestrated expansion celluliferous on the convex side. Here the branches vary in thickness from 0.4 to 0.6 mm., with about 15 in one cm.; their surface rounded and, when perfect, with a somewhat irregular series of strong tubercles, two or three to each fenestrule, along the middle; the zoœcia with circular or sometimes irregularly inflected apertures, about 0.09 mm. in diameter, separated by interspaces as wide or wider, and arranged in from three to five (usually four) only moderately regular alternating ranges, 21 or 22 in five mm.; the fenestrules irregularly oval, eleven in one cm.; the dissepiments short, their width as great or greater than the length of the fenestrules. On the reverse the fenestrules are circular or round oval and larger than on the obverse, the branches and dissepiments longitudinally striated in the young state, granulose, or with short vermicular striæ in older stages.

This well marked species was at first supposed to be identical with the *L. lyra* of Hall, but upon investigation proves to be quite distinct, as it now appears that that name was applied to only a variety of his *L. subquadrans*. The features that separate it from Hall's species are the stronger and subcylindrical form of the support, the absence of a slender base and the strongly convex form of the fenestrated expansion. The support closely resembles that of *L. quincuncialis* Hall, but that species has, excepting below a bifurcation, only two rows of zoœcia on the branches.

Position and locality: Chester group. Fragments of this specie are rare at Chester and Kaskaskia in Illinois. They are more abundant and better preserved at Sloan's Valley, Pulaski Co., Ky.

LYROPORA SUBQUADRANS Hall.

Pl. LVIII, Fig. 2-2e.

Lyropora subquadrans Hall, 1857. Proc. Amer. Ass. Ad. Sci., vol. 10, p. 180.

Zoarium with the thickened support and fenestrated expansion spread nearly in a plane, or with the celluliferous side somewhat convex. Support comparatively thin, pedunculate at the base, with the arms usually direct from the base, and diverging at an angle of 80° or more. Sometimes the sides of the support near the base are irregularly wrinkled. Entire height of zoarium not known to exceed six cm. On the obverse the branches appear rather rigid, generally about 0.6 mm. wide, 13 or 14 in one cm.; subangular, with a central row of small tubercles, five or six to each fenestrule. Zoœcia with small circular apertures, about 0.075 mm. in diameter, arranged regularly in four ranges, which are increased to five or six below a bifurcation; 22 or 23 in five mm. Fenestrules irregularly elliptical, about ten in one cm., separated by slightly depressed strong and short dissepiments, having a width about equal to the length of the fenestrules. On the reverse the branches and dissepiments are thinner and narrowly rounded, and the fenestrules larger, varying in form from suboval to subquadrate.

The less strong and different form of the support, the more rigid branches, more regular arrangement of the zoœcia apertures, and sub-quadrangular form of the fenestrules on the reverse, distinguish this species from *L. ranosculum* Ulr. Hall's description of the obverse differs somewhat from the above, but there can be no doubt about the identity of the specimens here described with the original examples.

I have failed to find any reliable characters upon which to distinguish Hall's *L. lyra* from this species. Fig. 2a (Pl. LVIII) represents a small example of what I regard as the typical form of *L. subquadrans*, while fig. 2 and 2b represent examples that are intermediate between it and the *L. lyra* form. A specimen before me (obtained since the plates were lithographed) seems to agree in every particular with Hall's description of his *lyra*. It also agrees with figure 2 in every respect excepting slight modifications in the form of the support, such as incurving abruptly outward and upward from the slender peduncle or base, instead of being nearly direct. Such small modifications, unless accompanied by more important differences, are scarcely sufficient even for varietal separation, since nearly every specimen examined by me offers some slight peculiarity. The *L. subquadrans* being the normal and more abundant form, it seems desirable that its name, although following *L. lyra* in the original paper, should take precedence.

Position and locality: Chester group. Rather common at Chester, Ill., and Sloan's Valley, Ky.

LYROPORA QUINCUNCIALIS Hall.

Pl. LVIII, Fig. 3-3d, and Pl. LV, Fig. 7-7c.

Lyropora quincuncialis Hall 1857. Proc. Amer Ass. Ad. Sci., vol. 10, p. 180.

In this species the support is very much as in *L. ranosculum*, but differs in being less strong and rather narrow oval instead of subcircular in cross section. The fenestrated expansion is also less convex, and in every respect the zoarium is less robust. Branches, on the obverse, rounded, 0.25 to 0.5 mm. wide, with a series of small tubercles along the middle, and two ranges of cell apertures excepting below a bifurcation where there are three; 24 or 25 in one cm. Apertures small, about 0.07 mm. in diameter and twenty-five in 5 mm. Fenestrules elliptical, sometimes appearing oblong quadrate, 16 or 17 in one cm. Dissepiments rather prominent. On the reverse the dissepiments are often more prominent and stronger than the branches, often forming short oblique or transverse ridges. At other times they are of about equal thickness and leave regular subcircular or oval fenestrules, having a diameter nearly or quite equal to the width of the branches.

Position and locality: Chester group. Fragments are common at Chester, Ill., and other localities, but good specimens are rare.

LYROPORA DIVERGENS Ulrich.

Pl. LVIII, Fig. 4-4b, 4d.

Zoarium small, with a peduncle or point of attachment below, from which the arms of the thickened support diverge at nearly a right angle and approximately in a direct line; the whole spread nearly upon the same plane. On the obverse the branches are usually a little flexuous and subangular, with a row of small tubercles, about three to each fenestrule, along the middle; 18 or 19 branches in one cm. Zoœcia in two rather irregular ranges, excepting a short distance below a bifurcation where there are three; apertures with a distinct peristome, comparatively large, about 0.1 mm. in diameter, and 22 in five mm. Fenestrules irregularly elliptical, indented by the zoœcia apertures, 12 or 13 in one cm. Dissepiments subangular, nearly as high as, and thinner than the branches. On the reverse the branches and dissepiments are rounded, of nearly equal thickness, and covered with fine vermicular striæ; the fenestrules round oval, varying in width with age, in younger examples being wider than the branches, in old ones narrower.

In having two rows of zoœcia this species resembles *L. quincuncialis* Hall, but differs in the form of the support, in having the expansion spread in a plane, and the zoœcia, fenestrules and branches a little larger. The apertures too are larger and have a distinct peristome, a feature not noticed in that species. The two ranges of zoœcia and the smaller branches will distinguish it from *L. subquadrans* Hall.

Position and locality: Chester group, Chester, Ill., and Sloan's Valley, Pulaski Co., Ky.

LYROPORA OVALIS Ulrich.

Pl. LVIII, Fig. 5-5b, and Pl. LV, Fig. 8.

Of this species I have seen only the imperfect example figured. It does not preserve any of the basal portion of the support, but the sides of the expansion are thickened in the manner usual for the genus. Contrary to the rule the reverse is the convex side. Here the branches are rounded and appear to inosculate, forming a regular net-work. leaving suboval or circular fenestrules, about ten in the length of 1 cm. Branches about sixteen in 1 cm., with a nearly smooth surface; their width, as a rule, is a little less than the transverse diameter of the fenestrules. The obverse being buried in the matrix, the arrangement of the zoœcia and and other features were determined by means of thin sections. These show that the zoœcia are larger than usual (especially wider) there being about twenty in five mm. The prevailing arrangement is in two ranges, but three rows occur for a distance of 2 or 3 mm. below the bifurcations. As shown by vertical section (Pl LV, fig. 8,) the inferior hemiseptum is situated higher up on the anterior wall than in other species.

The two ranges of zoœcia ally this species to *L. divergens* Ulr., and *L. quincuncialis* Hall, but the net-work is considerably larger than in those species. Both *L. subquadrans* Hall, and *L. ranosculum* Ulr., have from three to five rows of apertures.

Position and locality: Chester group, Grayson Springs, Kentucky.

POLYPORA McCoy, 1844.

(Synop. Carb. Foss. Ireland, p. 206.

(For generic diagnosis see page 396..)

In my estimate of this genus I regard such forms as *P. shumardi* and *P. varsoviensis*, as representing its most typical phase. McCoy's *P. dendroides* is one of a series (to which *P. cestriensis*, *P. tuberculata*, and *P. gracilis* also belong), that approaches *Thamniscus* too closely to make it a desirable type. I regard it as farther removed from *P. shumardi* than are the numerous two and three ranged forms.

POLYPORA SHUMARDI Prout.

Pl. LV, figs. 2-2d.

Polypora shumardi Prout, 1859. Trans. St. Louis Acad. Sci. Vol. 1, p. 271. Pl. 16, fig. 3-3b.

Polypora shumardi Hall, 1885. Rept. State Geol. for 1884, p. 35 Pl. 1, fig. 5.

Fenestella cultellata Hall, 1881. Trans. Alb. Inst. Vol. X. Abstract p. 21.

Fenestella (Polypora) cultellata Hall, 1883. Rept. State Geol. for 1882. Explanation to Pl. 29.

Fenestella cultellata Hall, 1886. Rept. State Geol. for 1885. Explanation to Pl. 41.

Fenestella cultellata Hall, 1887. Pal. N. Y. Vol. 6, p. 160.

Zoarium a large irregular fan-shaped expansion, the largest fragment seen being over 10 cm. high, and 12 cm. wide. Near the base and along the free margins there are, usually, strong root-like processes which may be attached to foreign bodies. Branches rather strong and straight, subangular, varying from 0.6 to 1.0 mm. in width, with eight or nine in one cm.; along the middle, on well preserved examples, with a series of elongate, strongly projecting, sharp, elevations or spines, about one to each fenestrule. Dissepiments half the width of the branches, depressed, rounded, often with a sharply margined irregular excavation or channel. Fenestrules narrow, elliptical, eight or nine in 1 cm. Zoœcia generally in four or five alternating longitudinal ranges, increasing to six or seven before bifurcation; about seventeen in 5 mm. Apertures circular, rather large, regularly and closely arranged, the not very well developed peristomes being almost in contact laterally. On the reverse the branches and dissepiments are rounded, commonly smooth, nearly on the same plane, the latter expanded at their junction with the former and about 0.6 mm. in length.

A very abundant and easily recognized species. Some of the silicified examples show the superior hemiseptum very clearly as a narrow crescentic plate projecting obliquely downward and forward from the posterior basal margin of the "vestibule." Other specimens have the superficial aperture closed by the usual opercular plate, the small perforation of which may be open or closed by a round stopper.

Position and locality: Upper Helderberg group. Falls of the Ohio, and Utica, Indiana.

POLYPORA BURLINGTONENSIS Ulrich.

Pl. LIX, figs. 2-2a.

Zoarium flabellate, at least 6 cm. wide, with strong root-like processes at the base. On the reverse the branches are moderately strong and straight, rounded, smooth, 0.6 to 1.0 mm. wide, and seven or eight in 1 cm. Dissepiments rather slender, somewhat depressed, one-half or less than half the width of the branches. Fenestrules subquadrate, 4.5 to 5 in 1 cm., about as wide as the branches, averaging 1.6 by 0.8 mm. None of the specimens show the obverse side satisfactorily, but as is learned from thin sections, the zoœcia are often in four, generally in five, and sometimes (just before bifurcation) in six alternating longitudinal series. Their apertures are about their diameter apart, with fourteen or fifteen in 5 mm.

Bryozoa are so rare in the Burlington limestone that the description of poorly preserved material from it is, in a measure, excusable. Moreover, the nature of the rock is such, that good specimens of this class are almost unknown. As near as can be determined *P. burlingtonensis* is closely allied to *P. halliana* Prout, of the Keokuk strata. The latter differs in having the reverse of the branches more narrowly rounded, and six fenestrules where this species has 4.5 to 5. Better specimens would probably show other distinctions.

Position and locality: Burlington limestone, Burlington, Ia., and Henderson Co., Illinois.

POLYPORA HALLIANA Prout.

Pl. LIX, figs. 5-5c.

Polypora halliana Prout., 1860. Trans. St. Louis Acad. Sci. Vol. 1, p. 580.

Polypora halliana Prout, 1866. Geo. Surv. Ill. Vol. 2, p. 421. Pl. XXI, fig. 4-4b.

(Not *Polypora halliana* Nich., 1874. Pal. Ont. p. 99.)

Zoarium large, expanding rapidly from a short, thick, finely striated foot-stalk, so that the margins quickly meet beneath it, or pass and overlap each other. The largest example seen measures 11 cm. from the outer margin to the sub-central foot-stalk. The inner half of the expansion is spread nearly in a plane, but towards the margins the frond is somewhat undulated. Near the footstalk the branches bifurcate frequently, are much curved, and have both sides thickened so that the fenestrules are smaller than farther out. The zoœcia apertures, also, are here entirely covered by a minutely granulose secondary deposit. Beyond its influence the characters of the zoarium are as follows: Branches 8 to 10 in 1 cm., moderately strong and straight, convex and minutely papillose when perfect, enlarging from 0.6 mm. just after, to 1.0 or 1.1 mm. just before a bifurcation. The width of a fully developed branch is quite uniform at 0.8 mm. Dissepiments rather slender, from 0.3 to 0.5 mm. wide, enlarging at their junction with the branches. Fenestrules six in 1 cm. varying from subquadrate to elliptical, about 1.3 by 0.5 mm. Zoœcia ranges increasing from three to six, the usual or normal number being four. Apertures small, without peristome, arranged alternately, about fifteen in 5 mm., in the usual state of preservation appearing oval, but when perfect decidedly pyriform the posterior margin being sinuate. On the reverse the branches have their summits narrowly rounded and their sides flattened, giving them a pinched appearance that is most marked toward the outer margin of the expansion. The dissepiments occupy nearly the same plane as the branches and the fenestrules are wider and more quadrate in form than on the obverse. When very young they are finely striated, but commonly they are smooth or covered with extremely minute granules.

This fine species is common and easily recognized by the characters above described.

Position and locality: Keokuk group: numerous localities in Illinois and Iowa. Warsaw beds, at Warsaw, Ill.

POLYPORA MACCOYANA Ulrich.

Pl. LIX, figs. 3-3d.

Zoarium a large, flabellate, slowly expanding frond. Branches six to eight in 1 cm., strong, rigid, subcylindrical, often with a row of widely separated and exceptionally large spines, which usually take the place of a cell aperture. Though varying from 0.6 to 1.2 mm., the average width of the branches is between 0.8 and 0.9 mm. Surface minutely granulose. Dissepiments slender, rounded, depressed. Fenestrules oblong subquadrate to elongate-oval, of variable width, averaging 2.4 by 0.8 mm., with 3 to 3.5 in 1 cm. Zoœcia in from four to eight alternating ranges, normally in five or six. Apertures fourteen or fifteen in 5 mm., subcircular, without peristome, appearing larger in worn examples than in perfect ones, widely separated longitudinally, and arranged in more or less regular intersecting diagonal series. Reverse of branches and dissepiments convex and finely striated.

This species, although closely related to *P. halliana* Prout, cannot be confounded with it. The fenestrules are so much longer, the branches stronger, more rigid and cylindrical. that a glance suffices to distinguish them. *P. simulatrix* resembles it more in its general aspect, but differs widely in important characters.

Position and locality: Keokuk group. Nauvoo and near Plymouth in Illinois, and Keokuk and Bentonsport, Iowa.

POLYPORA SIMULATRIX Ulrich.

Pl. LIX, fig. 4-4b.

Zoarium a large foliate expansion, with strong root-like appendages at the base. Branches moderately strong, slightly convex on the poriferous side, rather straight, bifurcating at long intervals, 0.7 to 1.3 mm. wide, with, generally, seven in 1 cm. Their average width between bifurcations is about 0.8 mm. Dissepiments one-fourth to one-third the width of the branches, expanding at their junction with them. Fenestrules 4 to 4.5 in 1 cm., varying from long-oval to sub-quadrangular, with average dimensions of about 2.0 by 0.6 mm. Zoœcia generally in five or six alternating ranges, twelve or thirteen in each in 5 mm. Apertures comparatively large, circular, surrounded by a well developed peristome, arranged obliquely across the branches or in regular diagonally intersecting lines, their diameter or a little more apart longitudinally. A few small spines, as shown in fig. 4b, are often present. On the reverse the branches are strongly rounded, somewhat flattened at the sides, and very finely striated.

Although in its general aspect this species is very much like *P. maccoyana*, there are still certain peculiarities which enable us to separate them easily. The larger number of fenestrules in a given space alone can be depended upon when the examples are badly worn, but more perfect ones show more important differences. The cell apertures in that species are smaller and without an elevated peristome, and the interspaces between them crowded with small granules. The branches are also more convex on the obverse side. The vestibular portion of the zoœcia again is longer, giving the branches a solidity and strength not possessed by those of *P. simulatrix*. Hence, while the branches of the latter are usually flattened by pressure, those of *P. maccoyana*, so far as observed, have always retained their convexity.

Position and locality: Keokuk group. Nauvoo, Warsaw and Henderson Co., Illinois, and Keokuk and Bentonsport, Iowa.

POLYPORA (?) GRACILIS Prout.

Pl. LXI, figs. 10, 10a.

Polypora gracilis Prout, 1860. Trans. St. Louis Acad. Sci. vol 1, p. 580.

Polypora gracilis Prout, 1866. Geol. Surv. Ill. vol. II, p. 422. Pl. XXI, figs. 1, 1a.

Zoarium a long, narrow, gradually spreading net-work, growing from a small pedicle. Branches strong, rounded, 0.8 to 1.2 mm. in width, with five or six in 1 cm.; bifurcating at variable intervals. Dissepiments very thin, slightly expanded at their junction with the branches. Fenestrules long, quadrangular or elliptical, usually a little wider than the branches. Their length varies greatly, the extremes noticed being 3 and 8 mm. Zoœcia in from three to five alternating ranges. Apertures small, circular, pustuloid when perfect, widely separated longitudinally, about nine in 5 mm. The branches are covered with granulose striæ, and on old examples there is a row of strong spines along the center of the branch. Reverse convex, smooth or finely striated.

In its growth this species approaches *Thamniscus*, but in its minute characters it closely resembles such species of *Polypora* as *P. maccoyana* and *P. halliana*.

Position and locality: Keokuk group. Warsaw and Nauvoo, Illinois, Keokuk, Iowa, and King's Mountain, Ky.

POLYPORA RETRORSA Ulrich.

Pl. LIX, figs. 6-6d.

Zoarium a small, rapidly expanding, foliar net-work. Branches 6.5 to 7 in 5 mm., rounded, slender, averaging 0.4 mm. in width, but increasing from 0.3 to 0.5 or 0.6 mm. before bifurcation takes place. Dissepiments short, depressed, half as wide as the branches. Fenestrules long-oval or sub-quadrangular, five or six in 5 mm., narrower than the branches. Zoœcia in three or four alternating ranges, in each about twenty in 5 mm. Apertures small, sub-oval, seemingly directed backward on account of the peristome, which is much the highest on the anterior side; sometimes with a rayed appearance. On the reverse the branches and dissepiments are rounded, occupy the same plane, are nearly of the same thickness, and exhibit numerous distinct granules, arranged in one or two encircling series. The fenestrules are shorter than on the obverse, and regularly elliptical in form.

The distinct granules and rounded fenestrules of the reverse, and the unequally developed peristome separate this species from, at any rate all the Carboniferous species of the genus, known to me.

Position and locality: Keokuk group. Rather rare at Keokuk, Iowa.

POLYPORA RADIALIS Ulrich.

Pl. LX, figs. 1-1*d*.

Zoarium very small, compact, two or three cm. in diameter, originally flabellate, but by expanding very rapidly the lateral margins at last meet and unite, giving it the appearance of a very much depressed funnel. Branches comparatively strong, close together, 0.3 to 0.5 mm. wide, and eight or nine in 5 mm., their surface minutely granulose. Dissepiments short, depressed, varying from one-fourth to two-thirds the width of the branches, their width depending largely upon the relative proximity of neighboring branches, being widest when these are nearest. Fenestrules small, irregular, sub-oval, about 0.5 by 0.2 mm., and between six and seven in 5 mm. Zoœcia in two ranges immediately after bifurcation, these soon increase to three, and then to four before the next division. Apertures circular, rayed, with prominent peristome, less than twice their diameter apart, about twelve in 3 mm. On the reverse the branches are rather straight, the dissepiments half as wide, the fenestrules sub-quadrate or elliptical, and twice as long as wide.

This beautiful little species is distinguished from its nearest relative *P. retrorsa*, by its closer branches, smaller fenestrules, their more elongate form, smooth and straighter branches on the reverse, and the direct apertures. The rayed apertures are also better shown in *P. radialis* than in any other species of the genus known to me.

Position and locality: Keokuk group. Rare at Keokuk, Iowa.

POLYPORA BISERIATA Ulrich.

Pl. LX, figs. 4-4*b*.

Zoarium a slowly expanding, irregular, more or less undulating, foliar net-work, from four to eight cms. in height. Branches closely approximated, seventeen to nineteen in 1 cm., slender, averaging 0.5 mm. in width, but increasing from 0.4 to 0.7 mm. before bifurcation, which takes place at intervals of from 5 to 14 mm. Their poriferous surface is nearly flat or slightly elevated centrally, where a row of prominent spines or nodes, about 0.45 mm. apart, almost gives the impression of a median keel. Dissepiments short, depressed, one-half or less than one-half the width of the branches. Fenestrules small, sub-oval, about fourteen in 1 cm. Zoœcia in two alternating ranges, increasing to three at a point 2 or 3 mm. below the branch divisions. Apertures large, 0.15 mm. in diameter, direct, with prominent peristome, seventeen or eighteen in 5 mm., their diameter or less apart, often closed by an opercular cover of the usual type. On the reverse the branches are rather broadly rounded, somewhat channeled below the bifurcations, and either smooth or very finely striated; the dissepiments thin and not depressed, and the fenestrules sub-quadrate.

The material upon which this species is founded is very satisfactory, many of the examples being free and in a fine state of preservation. The species is very constant and all the specimens, save one, agree closely in their measurements. The latter adheres to the rock and exposes the obverse side. So far as can be seen it agrees with the typical form in every respect excepting that the fenestrules are larger, there being only ten in 1 cm. It probably represents a variety.

The affinities of the species lie with *P. varsoviensis* Prout. That form is larger, has invariably one row of cells more to the branch, and larger fenestrules.

Position and locality: Warsaw beds. Monroe Co., Ill., and Warsaw, Ill. The same or a closely allied species occurs in the St. Louis limestone at Barrett's Station, Mo.

POLYPORA VARSOVIENSIS Prout.

Pl. LX, figs. 2-2b.

Polypora varsoviensis Prout, 1859. Trans. St. Louis Acad. Sci. Vol. 1, p. 236. Pl. 15, fig. 3-3b.

Zoarium a large irregular foliar expansion. Branches rather strong, rounded, nine to eleven in 1 cm., averaging 0.7 or 0.8 mm. in width, but increasing from 0.5 to 0.9 or 1.0 mm. before bifurcation takes place. Dissepiments short, slender, between 0.2 and 0.3 mm. thick. Fenestrules oval, somewhat irregular in size and shape, averaging 0.9 by 0.4 mm., with from 6 to 8.5 in 1 cm., the most common number being 7.5. Zoœcia at first in three alternating ranges, then in four, and, just before the branch again divides, in five. Apertures large, with a prominent peristome, their diameter or less apart, with fourteen or fifteen in 5 mm. On the reverse the branches are broadly rounded, smooth or finely striated, the dissepiments thin, the fenestrules nearly regularly elliptical, or occasionally, approaching subquadrangular, with their length fully equal to twice the width.

The larger dimensions of the fronds of this species distinguish them from *P. biseriata*. The two are almost constantly associated, and in both the zoœcia apertures are larger than usual. *P. simulatrix* of the Keokuk group agrees with them in this respect, but differs in having stronger branches and considerably larger fenestrules.

Position and locality: Warsaw beds. Abundant at Warsaw, Illinois, and Monroe Co., Illinois; also in the St. Louis limestone at Barrett's Station, St. Louis Co., Mo.

POLYPORA SPININODATA Ulrich.

Pl. LX, fig. 3.

Of this species I have only seen one large semi-circular frond in good preservation, and a smaller weather-worn fragment. Unfortunately both adhere firmly to the rock so that the reverse only can be seen. With the aid of thin sections the ranges of zoœcia have been determined. The characters of the reverse are as follows: Branches rather slender, varying from 0.3 to 0.6 or 0.7 mm., with thirteen to fifteen in 1 cm., bifurcating at long intervals. Their surface is strongly rounded, covered with distinct longitudinal striations, and raised, at intervals about equal to the length of a fenestrule, into pronounced spines or nodes. Dissepiments generally less than half the width of the branches, slightly depressed or on a level with the branches, subcarinate or narrowly rounded. Fenestrules elliptical, nine or ten in 1 cm., averaging 0.7 by 0.35 mm. Zoœcia at first in two ranges. then in three, and later on in four. The last number prevails for from 1 to 3 mm. before the branch divides.

The strong hollow nodes on the reverse of the branches, distinguish this species from all Carboniferous species of *Polypora* known to me. In the proportions and number of zoœcia the species occupies an intermediate portion between *P. biseriata* and *P. varsoviensis*. Thin sections also show some slight differences in their minute structure.

Position and locality: Warsaw beds, at Warsaw, Ill.

POLYPORA CESTRIENSIS Ulrich.

Pl. LV, figs. 4-4b, and Pl. LX, figs. 7-7c.

Zoaria consisting of foliar expansions of somewhat lax and irregular growth. Branches rather strong, slightly rounded, with a row of faint nodes along the center about 0.5 mm, apart; width above a bifurcation 0.5 mm., increasing to 1.0 mm., with about eight in 1 cm. Dissepiments slender, slightly depressed and expanded at each end, from 0.25 to 0.4 mm. thick; in some specimens with parallel striæ extending from branch to branch. Fenestrules rather large, narrow, sub-oval, with slightly indented margins, five or six in 1 cm., their average dimensions being 1.5 by 0.5 mm. Ranges of apertures alternating, increasing from three to four (the number immediately after bifurcation) to six just before the next division. Very young examples have the ranges of apertures separated by fine tortuous lines which become obsolete with age. Ordinarily the apertures are small, circular, pustuliform, generally about twice their diameter apart, with seventeen in 5 mm. On the reverse the branches are strongly convex, smooth, or with exceedingly fine longitudinal striæ. The fenestrules are wider and appear more nearly quadrangular than on the opposite face.

This easily recognized species is one of the most common and characteristic fossils of the Chester group. Its fronds are larger in every way than those of its nearest congener *P. tuberculata* Prout, while the pustiliform cell mouths and lax growth separate them from Keokuk and Warsaw species.

Position and locality: Chester group, at Chester, Kaskaskia, near Anna, and other localities in Illinois; also at Litchfield and Sloan's Valley, Ky.

POLYPORA TUBERCULATA Prout.

Pl. LX, fig. 8.

Polypora tuberculata Prout, 1859. Trans. St. Louis Acad. Sci. Vol. 1, p. 449, fig. 3, pl. 18.
Not *Polypora tuberculata* Nich., 1874. Pal. Ontario, p. 110, fig. 37.

Zoarium a small, flabellate net-work, not known to exceed 3.5 cm. in height. Branches twelve to fourteen in 1 cm., subcylindrical, slender, with an average width of 0.45 mm., but enlarging from about 0.3 to 0.6 mm, before bifurcation, which takes place at intervals varying from 1.5 to 8.0 or more mm. Along the middle of the branches there is an irregular row of moderately prominent and widely separated nodes, with only one or two in the length of a fenestrule. Dissepiments somewhat depressed, one-third to one-half the width of the branches. Fenestrules suboval but variable in size and shape, with average dimensions of 0.7 by 0.35 mm., and eight or nine in 1 cm.

Zoœcia normally in three or four, somewhat irregular, alternating ranges, just before bifurcation in five or six, and immediately after, rarely in two, generally in three. Apertures small, circular, when perfect somewhat pustuloid, about twenty-five in 5 mm. On the reverse the branches are rather narrowly rounded, slightly zigzag, and smooth or finely striated; the dissepiments scarcely depressed, and a little wider than on the opposite face; the fenestrules about as wide as the branches, and of oblong subquadrangular or subovate form. A few root-like apendages spring from the branches near the base, and occasionally farther up on the frond.

This species is on the order of, but in every way smaller than *P. cestriensis*. It has been erroneously identified in the Scotch Carboniferous shales by Mr. John Young. Mr. G. R. Vine,* after noting the resemblances and differences comes to the same conclusion, although his American examples of the species, are, as I have good reason to know, really quite different from Prout's *P. tuberculata*, and probably belong to *P. spinulifera* of this work. The slightly raised keel which Prout says separates the rows of cells in this species I have never seen, nor are the tuberculations so numerous as stated by him. These characters he probably obtained through confounding a fragment of *P. cestriensis* with the true *P. tuberculata*. His figure is quite reliable and shows the tubercles as above described, but no lines between the rows of cells. The dissepiments are represented a little too thin.

Position and locality: Chester group. Not uncommon at Chester, Ill.; rare at Litchfield, Ky.

POLYPORA CORTICOSA Ulrich.

Pl. LX, Figs. 5-5c, and Pl. LXI, Fig. 1.

Zoarium rather small, forming a flattened expansion, perhaps not exceeding three or four cm. in height, which springs from a strong, solid, finely striated foot-stalk. Both surfaces of the branches near the base are covered with the striated deposit, causing the fenestrules to become very small or entirely filled

*Notes on Yoredale Polyzoa, 1886, p. 17.

up. Beyond its influence the characters are as follows: Branches strong, broadly convex, eight or nine in 1 cm. with an average width of 0.8 mm., but increasing from about 0.6 mm. immediately after bifurcation to about 1.1 mm. before again dividing. Dissepiments short, slightly depressed, gradually decreasing in width from the base toward the free margin, where their width varies from 0.4 to 0.6 mm. Fenestrules comparatively small, oval, increasing in width outward, with 6 or 6.5 in 1 cm. Zoœcia at first in four alternating ranges, then in five, six, and seven rows (occasionally in eight) before the branch divides. Apertures about twenty in 5 mm., small, circular, with faint peristome, their diameter or more apart longitudinally, the rows separated by a fine wavy line that is alternately stronger and weaker and occasionally sufficiently elevated to form a small node or spine. On the reverse the branches and dissepiments are strongly rounded, upon the same plane, of nearly equal thickness, and finely striated. The branches being thinner than on the opposite face causes the fenestrules to be larger, their average dimensions being about 0.8 by 0.6 mm. Their form is somewhat variable, but, as a rule, they are broad-oval.

The seemingly disproportionate strength of the zoarium, and the striated solid tissue which is drawn over the basal portion of both sides, give this species a decidedly distinct appearance. In many respects the species resembles *P. complanata*, but that form is larger, more regular, has the zoœcia open down to the foot-stalk, the branches less convex and more uniform, the fenestrules smaller and circular, and no striations between the zoœcia apertures.

Position and locality: Chester group, Chester, Ill.

Polypora complanata Ulrich.

Pl. LX, Fig. 6–6c.

The above name is proposed for the specimen figured and one other. A number of fragments now before me may represent young examples of the same species but as their general appearance is more like that of *P. corticosa*, and, as none of them expand as rapidly as the types, I prefer to leave them unclassified for the present. The types which expose only the obverse side may be described as follows: Zoarium a semi-circular and slightly concave foliar expansion, 4 cm. wide and nearly 3 cm. high, growing from a short foot-stalk, with the branches scarcely distinguishable, the whole appearing rather as a rythmically perforated plate. Branches flat, bifurcating frequently and rapidly increasing in width from 0.7 to 1.5 mm. Dissepiments depressed, very short, extremely wide, the width equal to that of the branches and two or three times their length. Fenestrules circular, or nearly so, 0.3 to 0.5 mm. in diameter, with seven in 1 cm. Zoœcia in rather irregular ranges increasing in number from three or four to eight or nine between the bifurcations. Apertures nineteen or twenty in 5 mm., small, circular, when perfect with a faint peristome. Interspaces wider than the apertures, apparently set with inconspicuous nodes. From thin sections it appears that the reverse side of the branches is broadly rounded, and the dissepiments much depressed.

The examples from which the above description is drawn differ so much from the ordinary species of the genus that I do not hesitate in proposing a new name for them. The relation of the species to *P. corticosa* can only be determined by more complete examples than have as yet fallen under my notice.

Position and locality: Chester group, Chester, Ill.

Polypora spinulifera Ulrich.

Pl. LXI, Fig. 2-2a, 3-3a, 4-4a.

Zoarium a foliar, fan shaped, undulated or flat, expansion 4 or 5 cms. in height. Branches rather slender, gently convex, about thirteen in 1 cm., and from 0.5 to 0.8 mm. in width. Surface spinulose, the spines small, about two-thirds as numerous as the zoœcia, and irregularly distributed. Dissepiments short, rounded, depressed, from one-third to one-half as wide as the branches. Fenestrules irregularly oval, more or less indented, 9.5 to 11 in 1 cm.; on an average 0.6 by 0.3 mm. Zoœcia in from three to five alternating ranges, these numbers being the extremes between the bifurcations. The prevailing number is four. Apertures small, with well developed peristome, twenty to twenty-one in 5 mm., regularly arranged between the small tubercles. On the reverse the dissepiments are about as wide as the branches, and both are strongly convex and smooth, while the fenestrules are regularly broad-oval or subcircular, they and the dissepiments being wider and the branches narrower than on the obverse side.

A variety of this species is represented by figs. 3 and 3a. It is from the Coal Measures in Montgomery Co., Ill., and differs from the typical form in having three as the prevailing number of zoœcia ranges, narrower branches, and wider, subquadrangular fenestrules. The zoœcia are also a little larger, there being only eighteen or nineteen in 5 mm. The form represented by figs. 4 and 4a, is also from the Coal Measures. It agrees more closely with the typical form, differing mainly in having the fenestrules slightly shorter and the dissepiments correspondingly stronger. In the number of cell rows it is intermediate between the Chester form and the Montgomery Co. variety.

Position and locality: Chester group, Chester, Ill., and Monroe Co., Ill. Coal Measures, Montgomery Co., Ill., and near Red Oak, Iowa.

POLYPORA APPROXIMATA Ulrich.

Pl. LXI, Figs. 5-5a.

Polypora biarmica Prout, (non Keyserling) 1859. Trans. St. Louis Acad. Sci., vol. 1, p. 450.

This is probably only a well marked variety of *P. spinulifera*, but it is sufficiently distinct to deserve a name. It differs in the following respects: The zoarium is stronger and in every way presents a more robust aspect, the branches and dissepiments being somewhat wider, and the fenestrules larger, especially upon the reverse side. There are seven to nine fenestrules instead of ten or eleven. The number of cell ranges increases quite regularly from three or four just after a bifurcation, to six or seven before the next division. The nodes or spines are stronger, much less in number, and generally occupy only the center of the branches.*

Position and locality: Chester group, Chester, Ill.; Sloan's Valley and Litchfield, Ky.

*I have lately collected several hundred examples of this species, showing it to be a constant form and qui e distinct from *P. spinulifera*. The specimens were obtained from near Clayton P. O., Caldwell Co., Ky., where they occurred in a bed of shaly limestone at the top of the Chester.

POLYPORA WHITEI Ulrich.

Pl. LXII, Fig. 2.

Zoarium a delicate, slowly expanding, foliar net-work, branches very slender, rigid, varying from 0.25 to 0.5 mm. wide, with nine or ten in 5 mm. Dissepiments slender, about 0.1 mm. thick, enlarging at each end. Fenestrules subovate, nearly as wide as the branches, 0.7 by 0.25 mm. their average dimensions, with six in 5 mm. Zoœcia in two and three rows excepting just below a bifurcation where a fourth is interpolated. The ranges are separated by an interrupted or continuous keel, which gives the branches so long as they have only two ranges of cells, very much the appearance of a *Fenestella*. At intervals the keel is slightly elevated so as to form a small node. Apertures circular or faintly truncated at the posterior side, with a thin peristome, about nineteen in 5 mm. The longitudinal spaces between the apertures are equal to nearly twice their diameter, and usually marked by two or three raised lines. Reverse not seen.

In this species we see, perhaps, the last of the numerous links between *Fenestella* and *Polypora*. Such species have been described from the Niagara and all the principal horizons between that and the Hamilton group, but have not, heretofore, been known from Carboniferous deposits.

It gives me much pleasure to name this beautiful species for my esteemed and distinguished friend, Dr. Charles A. White, of Washington, D. C.

Position and locality: Base of Coal Measures, Seville, Ill.

POLYPORA WHITEI var. INSCULPTA n. var.

Pl. LXII, fig. 1.

This variety or species closely resembles the type of *P. eximia* but differs in the following points. The branches are slightly wider, less rigid, the two ranges of zoœcia sooner give way to three and these to four, the separating ridges are more irregular, the finer lines wanting, the peristomes more elevated and thicker, and the fenestrules larger, there being only 4.5 in 5 mm.

Position and locality: Upper Coal Measures, at Springfield, Illinois.

POLYPORA NODOCARINATA Ulrich.

Pl. LXI. fig. 9-9a.

Zoarium infundibuliform, large, thrown into strong folds toward the upper margin, poriferous on the inner side. Branches moderately strong, rigid, averaging ten to 1 cm., 0.5 or 0.6 mm. wide at a point immediately above a bifurcation; the width gradually increases to 0.7 mm., which prevails till a short distance below the next bifurcation when another 0.1 mm. is added The bifurcations being widely separated, the increase is very gradual. Dissepiments short, depressed, rounded, 0.3 or 0.4 mm. wide. Fenestrules oval or subquadrangular, about 0.7 by 0.3 mm., and 8.5 or 9 in 1 cm. Zoœcia in four regular alternating ranges, excepting for a short distance after bifurcation where three is the prevailing number, and occasionally just before bifurcation where a fifth row may be developed. Apertures circular, without a peristome, about their diameter apart, nineteen in 5 mm. The ranges of apertures are separated by three rows of tubercles, of which the central row is much the most conspicuous, giving the branch the nodo-carinate appearance that has suggested the name. Frequently, however, the tubercles occupy the longitudinal spaces between the cell apertures when that appearance is less marked. On the reverse the branches are narrowly rounded and appear very thin, the fenestrules are larger, averaging 0. 8 by 0.7 mm., nearly square, or slightly hexagonal. The surface of the branches is smooth over the lower half of the zoarium, and finely striate toward the upper margin.

The subcarinate branches, with their four ranges of apertures bring to mind *Fenestralia sancti-ludovici* Prout. This character, and the nearly square form of the fenestrules on the reverse, distinguish the species from all Carboniferous *Polyporæ* known to me.

Position and locality: Upper Coal Measures; Crooked Creek, near Centralia, Ill.; also in Macoupin Co.

POLYPORA SUBMARGINATA Meek.

Pl. LXI, fig. 6-6b.

Polypora m-rginata Geinitz, 1866. Carb. u. Dyas in Neb. p. 69, Pl. 5, figs, 11, a, b, and 12 a, b, (not McCoy, 1844, Syn. Carb. Foss. Ireland p. 206, Pl. 29, fig. 5.)

Polypora submarginata Meek, 1871. Pal. E. Neb. p. 154, Pl. 7, figs. 7a, 7b.

Zoarium flabelliform, probably not exceeding three or four cm. in height. Branches about seven in 1 cm., sub-pentagonal in cross section, with the obverse side strongly convex, subcarinate when typical, and carrying a row of small, conical, rather prominent spines or tubercles along the middle, about 0.3 mm. apart; the two lateral margins sharply angular. The average width of the branches is about 0.7 mm., but gradually increases from 0.5 mm. to 1.0 mm. between the bifurcations. Dissepiments rather long, slender, 0.3 to 0.5 mm. wide, spreading slightly at each end, faintly striated or smooth, narrowly rounded. Fenestrules oblong oval to subquadrangular, about as wide as the branches, twice as long, averaging 1.7 by 0.8 mm., and 4 to 4.5 in 1 cm. Zoœcia five or six to the fenestrule generally in five ranges, which number may be increased to six just before bifurcation. Immediately after, but only for a short distance, there are only three or four ranges. Apertures circular, 0.11 mm. in diameter, nearly twice their diameter apart longitudinally, about fifteen in 5 mm., rather irregularly arranged, with a well developed but not strong peristome. In a normal development the apertures of the central range alternate with the tubercles. On the reverse the branches are narrowly rounded, flattened on the sides, and smooth or finely striated. Near the base they are irregular, the dissepiments nearly as strong and on a level with the branches. The fenestrules are large, oblong subquadrate, or irregular.

This distinct and common species is very characteristic of the Upper Coal Measures of the western states. It is on the order of, but much larger than the *P. nodocarinata*. Associated with it in Illinois, I have met with a smaller species having no tubercles and 5.5 fenestrules to 1 cm. The latter also occurs in the Lower Coal Measures, from which I have obtained good specimens. These have fine waving ridges between the rows of cell apertures, agreeing in this and other respects rather closely with McCoy's *P. marginata*.

Position and locality: Upper Coal Measures, Macoupin Co., Illinois, LaSalle and Springfield, Illinois, near Red Oak, Iowa, Nebraska City, Neb., and other localities.

POLYPORA DISTINCTA Ulrich.

Pl. LXI, fig. 7-7a.

Zoarium a foliar expansion of unknown dimensions, forming a loose net-work. Branches rather strong, not rigid, moderately convex, 0.7 to 1.4 mm. wide, about five in 6.5 mm. Dissepiments short, depressed, varying in width from 0.4 to 0.7 mm. Fenestrules usually a little narrower than the branches, varying greatly in length, the extremes noticed being 2.7 and 4.5 mm., but most of them vary between 3.5 and 4.0 mm., while the average width may be put down at about 0.6 mm. Zoœcia in from four to six ranges. These are increased to seven or eight just before bifurcation. Apertures subcircular, often slightly sinuate at the lower margin, arranged in rather regular diagonally intersecting series, in which five occupy a space about 1.4 mm. long; longitudinally thirteen or fourteen occur in 5 mm. Peristome moderately strong, but wanting at the lower side, causing the apertures to appear slightly oblique. Interspaces wide, with an occasional node, and when well preserved, minutely granulose. Reverse strongly rounded, finely striated or smooth.

The long fenestrules and general appearance of the zoarium suggests a relationship to *P. gracilis* and *P. maccoyana* of the Keokuk group. The incomplete peristome, more crowded zoœcia, and less convex branches, distinguish it from the first, while the greater length of the fenestrules, less rigid branches and other differences, separate it from the second. *P. grandis* Toula, and *P. gigantea* Waagen and Pichl, are larger in every respect.

Position and locality: Upper Coal Measures; Springfield, Ill.

POLYPORA CRASSA (Provisional.)

Pl. LXI, fig. 8-8*a*.

Zoarium a rapidly expanding flat net-work, 4 cms. in width. Branches strong, broadly convex, bifurcating frequently, five to six and one-half in 1 cm., and from 0.9 to 1.3 mm. in width. Dissepiments of variable width. Fenestrules oblong oval, generally a little narrower than the branches, and three or four times longer than wide, usually 2.4 by 0.7 mm. and 3.5 in 1 cm. Zoœcia in from five to eight ranges. Apertures circular, arranged in more or less regular diagonally intersecting series, in which four occur in the space of 1 mm. Longitudinally about eleven in 3 mm. The zoœcia apertures usually do not extend to the margin of the branches.

The specimen for which the above name is provisionally proposed, is not sufficiently preserved to render its specific determination satisfactory. It is proportionately larger than *P. corticosa*. The *P. koninckiana*, lately described by Waagen and Pichl from the Permo-carboniferous deposits of India, agrees in many respects, but I do not believe them identical. Better specimens of the American form are necessary before its affinities can be ascertained.

Position and locality: Upper Coal Measures, Sugar Creek, Sangamon county, Illinois.

FENESTRALIA Prout, 1859.

(Trans. St. Louis Acad. Sci. Vol. I, p. 235.)

(For generic diagnosis see page 396.)

The validity of this genus is provisionally admitted because of the importance of the carina among the FENESTELLIDÆ. Beyond this feature, *F. sancti-ludovici* differs in no respect from *Polypora*, unless we credit the fact that the rows of cells are constantly four, with generic importance.

FENESTRALIA SANCTI-LUDOVICI Prout.

Pl. LV, fig. 5.

Fenestralia St. Ludovici Prout, 1859. Trans. St. Louis Acad. Nat. Sci. Vol. I, p. 235, Pl. 15, figs. 1-1a.

Zoarium a large flabelliform expansion. Branches 9.5 to 11.5 in 1 cm., rather slender and unequal, somewhat rigid, strongly carinated, the aperture bearing surfaces either flat or slightly convex; average width of branches 0.6 mm., increasing from

0.5 to 0.7 or 0.8 mm. between the bifurcations. Dissepiments rounded, depressed, expanding but little at their ends, about two-thirds the width of the branches. Fenestrules oblong subquadrangular or oval, their width varying from one-fourth to one-half the length; about six in 1 cm. longitudinally. Carina strong, rounded, dilating into prominent elongated tubercles at intervals of 1 mm. Zoœcia in four ranges, two on each side of the carina. Apertures sometimes alternating, usually opposite, those of the lower ranges opening obliquely or directly into the fenestrules and often obscured by those of the upper rows. When the matrix completely fills the fenestrules the lower rows are not seen and the specimens might be mistaken for *Fenestella.* There are six or seven apertures in each row to a fenestrule, one of them opposite each dissepiment. The apertures are of medium size, surrounded by a thin peristome, their diameter or a little more apart, with eighteen in 5 mm.

On the reverse the branches are narrowly rounded, smooth or finely granulose, have sloping sides, are straight or slightly zigzag, and appear much thicker than on the opposite side. The dissepiments are straight, nearly as strong as the branches, and but little if at all depressed. The fenestrules vary considerably in width, but are always wider than the branches, and once and a half or twice as wide as on the obverse face. In form they vary from quadrangular to hexagonal.

The above describes the typical form as it is found in the St. Louis limestone at Alton, Illinois, and St. Louis, Mo. Prout's figures are faulty in having the dissepiments as high as the branches when they are really depressed. In the Warsaw beds there is a variety that appears to agree in every respect excepting that its branches are invariably somewhat thinner. A more distinct variety or species differs as follows:

var. COMPACTA n. var.

Pl. LIX, Fig. 1.

The branches are as a rule a little thinner and closer together there being 11.5 to 12.5 in 1 cm.; the nodes on the keel inconspicuous or wanting, but large nodes often occur on the reverse. The dissepiments depressed, rather strong and rounded, the fenestrules oval, nearly or quite as wide as the branches, eight in 1 cm. The zoœcia have prominent mouths, with twenty or twenty-one in 5 mm. The variety thus appears to be more compact in every way than the typical form.

Position and locality: St. Louis group and Warsaw beds. St. Louis and Barrett's Station, Mo. Alton, Columbia, Warsaw and localities in Monroe Co., Ill. The variety is from Elizabethtown, Ky., where it was found associated with typical St. Louis fossils.

THAMNISCUS King, 1849.

(Ann. & Mag. Nat. Hist. 2d ser., Vol. III. p. 389.)

(For generic diagnosis, see page 397.)

This genus was founded by King upon the Permian fossil *Keratophytes dubius* Schlotheim. It also seems evident that King intended to include Silurian and other forms as well, but to arrive at a true and conclusive idea of the genus the characters of the type species alone can be depended upon.

King's description of *T. dubius* has been shown to the erroneous in several important respects by Mr. G. W. Shrubsole.* He shows that the supposed "gemmuliferous vehicles," only represent the broken or worn hollow spines, and that the zoœcia apertures are provided with an elevated peristome. These observations I can verify, having lately studied a series of German specimens which were procured for the purpose. I find, further, that the poriferous face of the branches is in every essential respect identical with that of such species of *Polypora* as *P. cestriensis* and *P. spinulifera*. Some of my own specimens being in a good state of preservation show the nodes or spines and the peristomes very well, and that the latter are especially prominent about the apertures of the marginal zoœcia. The nodes are numerous and occur on two or three faint longitudinal lines which run between the ranges of apertures. Another character that aids in linking the genus to *Polypora* is shown by the two specimens figured on plate 62. There is an occasional dissepiment, which unites the branches when, after bifur-

* Quart. Jour. Geol. Soc. for Aug., 1882, p. 341.

cation, they are brought close together. Though developed less numerously and shorter than they are in *T. ramulosus* and *divaricans*, it is now evident that the total absence of dissepiments can no longer be insisted upon as one of the distinguishing features of *Thamniscus*, but we must fall back upon the frequent dichotomization of the branches as the only remaining diagnostic character. Of course the relative paucity of the dissepiments aid very materially in separating species of the genus from those of *Polypora*, yet a sharp divisional line between these two groups is out of the question. In fact, I think that a very nearly complete line of development can be shown between *T. dubius* and *Polypora* in which *P. dendroides* (McCoy) *P. gracilis* (Prout) *T. divaricans* and *T. ramulosus* would figure prominently. The question, what about the Silurian and Devonian species which have been placed under *Thamniscus?*, I cannot enter into at present, beyond the simple expression of my belief that none of them belong to the special line of development that culminated in *T. dubius*, unless, perchance, we agree that the tendency to deviate in that direction was retained by certain forms which may have reverted to the parent branch, and only required the proper condition to again assert itself. It does not, however, seem at all probable that all of them were subjected to this possible reversion, since in *T. sculptilis* and *T. octonarius*, we have two species that are most probably descendants of the more ancient line. Some of the Devonian species complicate the geneological problem by presenting marked external resemblances to *Idmonea*, but how far the agreement may be the result of true relationship remains to be determined.

For the present we my say that *Thamniscus*, as now understood, commences in the Niagara with one species,* is represented by two species in the Lower Helderberg, continues through the various Devonian and Carboniferous groups, and culminates in the Permian formation. Neither the species, of which the total number is about sixteen, nor the individuals seem at any time to have been abundant.

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* Hall's *T. niagarensis* belongs to my new genus *Drymotrypa*, but his *Hornera? dichotoma*, is closely allied to the Wenlock *Thamniscus crassus* Lonsdale sp.

THAMNISCUS DIVARICANS Ulrich.

Pl. LXII, fig. 6-6c.

Zoarium consisting of rather stout, remotely bifurcating branches spread in a plane. The bifurcations, though terminal, usually seem all to spring from one side of a primary branch, giving the zoarium the appearance of unilateral development. The branches are more or less nearly parallel, and, whenever they are brought into close proximity, are united to each other by thin dissepiments. On the reverse they are rather strongly rounded and covered with very fine longitudinal striæ; on the obverse, slightly convex, 1.0 to 1.5 mm. in width, with dentate margins due to the lateral projection of the marginal ranges of zoœcia mouths. Zoœcia in from five to seven ranges. Apertures sub-circular, about 0.1 mm. in diameter, arranged in parallel elevated series curving outward and upward from the center to each margin of a branch very similar to the arrangement in certain species of *Idmonea.* About eight of the V-shaped series occur in the length of 5 mm. The apertures really occupy the summits of ridges which increase considerably in height toward the margins of the branches. The transverse spaces between the apertures are more or less depressed, but not nearly so much as the spaces which separate the ridges. When perfectly preserved, all the interspaces are finely granulo-striate, the striations having a longitudinal direction.

This is an unequivocal species of *Thamniscus,* and somewhat resembles the *T. serialis* Waagen and Pichl, from the Upper Carboniferous rocks of India. It also resembles the associated *Polypora? gracilis* Prout, especially when the branches are united by unusually numerous dissepiments, as in the example represented by fig. 6b.

Position and locality: Keokuk group, King's Mountain, Ky.

THAMNISCUS SCULPTILIS Ulrich.

Pl. LXII, fig. 8, 8b.

Zoarium small, consisting of slender, subcylindrical branches, from 0.4 to 0.8 mm. in width, which bifurcate two or three times at intervals varying from 3 to 4 mm. Angle of bifurcation very wide, usually about 90°. Zoœcia small, in from five to nine ranges. About two-thirds the circumference of the branches is taken up by their apertures, the remaining third being non-celluliferous, and smooth or very finely striated. On the obverse face of the widest examples the zoœcia apertures are arranged in oblique curved series very much as in *T. divaricans* (Pl. 62, fig. 6a). The series, however, are much closer together, there being ten in 3 mm., the apertures smaller (about 0.07 mm. in diameter,) less pronounced, and surrounded by a thin peristome. The central rows especially are also arranged in longitudinal series between distinct elevated lines, causing the formation of a deeply concave oblong space behind each aperture. As intimated, this concave space becomes gradually less distinct on the sides of a branch, and disappears entirely before reaching the irregular rows that margin the non-celluliferous space. In narrow or young examples the arrangement is as shown in fig. 8a.

This species is peculiar in the wide angle at which the branches bifurcate, the depressed space behind the zoœcia apertures, the small size of the zoœcia, the subcylindrical form of the branches, and the narrow non-poriferous space. These features distinguish it from all the species of the genus known to me.

Position and locality: Keokuk group, King's Mountain, Ky.

THAMNISCUS FURCILLATUS Ulrich.

Pl. LXII, fig. 9,9b.

Zoarium small, consisting of slender, dichotomously divided branches, increasing very gradually from 0.5 to 0.6 or 0.7 mm., between the bifurcations. Bifurcations terminal, widely separated, rarely less than 7 mm. apart, but varying between the extremes of 4 and 9 mm. Angle of bifurcation between 60° and 90°. Zoœcia usually in four ranges; in three or four just after, and four or five just before bifurcations. Apertures small, subcircular, 0.08 mm. in diameter, about seventeen in 5 mm., with a peristome, alternating in adjoining rows, the rows separated by more or less continuous elevated lines, which often carry small nodes. The nodes, however, are never conspicuous. Both surfaces moderately convex, the width of a branch being greater than its thickness. When well preserved the reverse side is finely striated.

This is one of the most characteristic species of the Chester group, being moderately abundant at all of the typical localities where the horizon is exposed. It is also very distinct from all the American forms, the principal peculiarities being the four ranges of zoœcia and the slender branches. A similar species is described by Mr. G. R. Vine from the carboniferous shales of England, as *T. gracilis*.

Position and locality: Chester group, Chester, Kaskaskia, and other localities in Illinois, and Sloan's Valley and Litchfield in Kentucky.

THAMNISCUS RAMULOSUS Ulrich.

Pl. LXII, fig. 4—4b.

Zoarium a small frond, composed of delicate, frequently bifurcating branches, the bifurcations occurring at intervals of 1 or 2 mm. Branches rounded, from 0.3 to 0.5 mm. wide, two-thirds as thick, connected to each other by slender dissepiments, which never outnumber the bifurcations. Zoœcia increasing from three to five ranges between the bifurcations. Apertures small, pustuliform, about 0.08 mm. in diameter, several times their diameter apart, not very regularly arranged in oblique transverse rows, with twelve in 3 mm. A small tubercle may now and then be detected. Reverse with five or more longitudinal striæ, which are less distinct near the base of the frond.

var. SEVILLENSIS Ulrich.

Pl. LV, fig. 6, and Pl. LXII, figs. 5-5a.

In this variety the zoarium spreads more rapidly than in the typical form. The zoœcia and their apertures are somewhat larger, there being only nine or ten of them in 3 mm., while there are also never more than four, and usually only three ranges throughout. The best specimen seen is slightly abraded, yet shows faint evidences of granulose striations on the interspaces.

This species, though having the branches united by dissepiments whenever they approach each other closely enough, is nevertheless a true species of *Thamniscus*. The fact that dissepiments are also occasionally present in *T. dubius*, the type of the genus, invalidates all objection to them in other species having the really essential characters of the genus. Compared with *T. divaricans*, the present species will be found much smaller, the branches more frequently bifurcated, and the zoœcia apertures differently arranged. A more nearly related species occurs in the Keokuk group at King's Mountain, Ky. It differs mainly in having stronger branches.

Position and locality: The typical form is from the Chester group at Sloan's Valley, Ky., and has also been noticed on slabs from Chester, Ill. The variety is from the Lower Coal Measures at Seville, Ill.

THAMNISCUS OCTONARIUS Ulrich.

Pl. LXII, Fig. 7-7b.

Zoarium a small flabellate frond, somewhat higher than wide, produced by frequent bilateral dichotomization of a zigzag primary branch. The bifurcations take place at such short intervals that the spaces which separated the branches are usually of less width than the branches. The angles between the bifurcating branches are rounded, while the separating ranges of zoœcia form acute angles, the intervals being occupied by subtriangular or wedge-shaped, concave, solid spaces. Obverse face of branches moderately convex, 1.1 to 1.3 mm. wide. Zoœcia ranges increasing rapidly in number from three or four to seven or eight between the bifurcations. Apertures circular, about 0.07 mm. in diameter, arranged in longitudinal series between obscure raised lines, fifteen or sixteen in 5 mm., and in more or less regular diagonal series. Peristome gradually rising about the aperture, incomplete at its lower margin, spreading again and gradually becoming obsolete below the aperture so as to enclose a faintly margined circular suboval depression. At the bottom of this depression (which with the aperture resembles the figure 8), I have in several instances detected a small pore. Reverse convex, appearing smooth under the ordinary hand lens.

This interesting species brings to mind several chilostomatous Bryozoa, but, for the present at least, is fittingly referred to *Thamniscus*. The superficial character of the zoœcia, in fact, the whole obverse face of the zoarium is quite different from that of the ordinary species of the genus, making detailed comparisons unnecessary.

Position and locality: Upper Coal Measures; Greenwood Co., Kansas.

PHYLLOPORA King, 1849.

(Mon. Permian Fos. England, p. 40.)

(For generic diagnosis see page 397.)

The characters of this genus, as determined by an examination of *P. ehrenbergi* King, the type of the genus, place it in the immediate neighborhood of *Polypora*. In its zoœcial characters the type species agrees thoroughly with *Polypora*, the most important difference between the two genera being that, while in the latter, the branches are approximately straight and united to each other by rythmically developed non-poriferous bars, called dissepiments, they unite by inosculation to form a regular round or oval-meshed network in *Phyllopora*. The earliest true *Phyllopora* known to me is from the Upper Helderberg group, and is next described under the name of *P. aspera*. The Silurian *Retepora* species which I and others have placed in this genus, are now known to possess very different zoœcia, and must be referred elsewhere, but mainly to the new genus *Phylloporina*.

In American rocks true species of *Phyllopora* are very rare, and up to this time I have met with only two undoubted species, both of which are here described. A somewhat doubtful third form is partially illustrated on plate LV. It agrees with *P. superba* in having sub-rhomboidal fenestrules on the reverse, but on the obverse its branches are more distinct and occasionally separated by a narrow non-celluliferous strip. Several species of this type occur in the Hamilton group of New York and Canada. It is not easy to decide whether they had better go with *Phyllopora* or *Polypora*.

PHYLLOPORA ASPERA Ulrich.

Pl. XLIV, figs. 5-5*b*.

Zoarium infundibuliform, celluliferous on the outer side, consisting of anastomosing branches, forming a regular round meshed net-work. Branches rather strongly convex, from 0.4 to 0.6 mm. wide. Fenestrules broad oval or circular, 0.2 or 0.3 mm. in diameter, smallest near the base, arranged in sub-regular longitudinal and diagonally intersecting series, with five lengthwise and six diagonally in 5 mm. Zoœcia in two or three, usually alternating ranges. Apertures circular, about 0.13 mm. in diameter, so far as observed, without a peristome, their diameter or less apart, rather irregularly arranged, thirteen or fourteen in 3 mm. Distributed over the surface among the apertures are a variable number of strong blunt spines, giving this face of the zoarium the rough aspect that suggested the name. On the reverse the fenestrules are nearly or quite as wide as the branches. Surface of the latter smooth or minutely granulose.

The small size of the zoarium and fenestrules, and the arrangement of the zoœcia in only two or three rows on a branch, distinguish this species from all others of the genus, save one, known to me. The arrangement of the zoœcia is very much as in *P. ehrenbergi*.

Position and locality: Upper Helderberg group. Rare at the Falls of the Ohio.

PHYLLOPORA SUPERBA Ulrich.

Pl. XLIV, figs. 6-6c, and Pl. LV, figs. 9, 9a.

Zoarium a reticulated flabellate expansion, known to attain a height and width of between 4 and 5 cms.

Obverse face: Here the branches are strongly rounded, from 0.6 to 1 mm. wide, and appear to alternately approach and recede from each other, so as to form elongate lozenge-shaped fenestrules. Generally a narrow depression marks the line of junction between the branches, causing the fenestrules to appear confluent. The fenestrules are arranged in regular, diagonally intersecting and longitudinal series, with respectively 5.5 to 6 and 3.5 to 4 in the length of 1 cm., each way. Zoœcia usually in four ranges, with three or five occasionally prevailing for a short distance. Apertures sub-circular, small, with well developed but somewhat oblique peristomes, arranged in more or less regular transverse rows, of which about seventeen occur in 5 mm. Transversely the apertures are about their diameter apart, but longitudinally the interspace is about twice as great.

Reverse face: Here the branches are smooth, narrowly rounded or angular, and with nearly flat sloping sides; the fenestrules commonly rhomboidal, but sometimes regularly hexagonal, and arranged in more or less curved intersecting series. When of rhomboidal form there are exactly six in 1 cm., measuring diagonally, and four in the same space vertically.

This beautiful species is distinguished from all the Hamilton Bryozoa known to me by its large fenestrules and the total absence of non-poriferous dissepiments. Two or three smaller, yet very similar species, occur in the Upper Helderberg and Hamilton groups, but all of them have their zigzag branches united by appreciable, though very short and wide, dissepiments.

Position and locality: Hamilton group, Erie Co., N. Y.

PINNATOPORA Vine, 1883.*

(Fourth British Asso. Rept. on Foss Poly. p. 31.)

(For generic diagnosis see page 397.)

This name justly supplants *Glauconome* in its common use for Palæozoic Bryozoa, the original species of that genus, being of a very different type, and most probably congeneric with those for which Defrance previously proposed the now well es-

* The same name and for the same group of species was proposed by Mr. Shrubsole in 1884 (Proc. Chester Soc. Nat. Hist.) and conjointly by him and Mr. Vine in the May number of the Quart. Jour. Geol Soc., 1884.

tablished name *Vincularia*. Both Vine and Shrubsole suggest that the name *Glauconome* be retained for the *G. disticha* Lonsdale, of the Wenlock shales. Perhaps d'Orbigny's name *Penneretepora* has a better claim. Should it prove upon investigation that the Eifel species *G. disticha* Goldf. is again generically distinct from both the Wenlock species and *Pinnatopora*, then all the names might stand. In any event I believe we cannot do better than to accept *Pinnatopora* as defined by Vine.

All the American species described under *Glauconome* have the characters of *Pinnatopora*. There are four from the Devonian by Hall, and one each by Meek and White from the Coal Measures. Fifteen or sixteen species referable to the genus have been described from the Carboniferous deposits of Europe, and one lately, from the Coal Measures of Ohio, by Foerste. The following new forms bring the total number to 29 or 30 species*.

On plate LVI will be found figures of five species of the genus illustrating variations in internal structure. In *P. elegans*, *P. conferta* and *P. trilineata*, the zoœcia form two distinct ranges in both the midrib and branches, in *P. retroflexa*, those of the midrib are somewhat lozenge-shaped, so that the cells of each range are in contact only at their pointed extremities, while, in *P. laxa*, they form one range in both midrib and branches. The other species present each some slight intermediate modification of zoœcial form and arrangement. Hemisepta are, as a rule, but little developed in *Pinnatopora*, but in *P. trilineata* they are exceptionally strong.

PINNATOPORA YOUNGI Ulrich.

Pl. LXVI, fig. 3.

Zoarium pinnated, comparatively strong. Midrib strong, averaging 0.6 wide, with the reverse side broadly convex and finely striated. Obverse side somewhat flattened, with a strong,

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*In December, 1888, (Bullet. Laboratories Denison Univ., Vol. 4,) the author published description and figures of five additional species. These are from the Cuyahoga shales of the Waverly series of Ohio.

rounded, mesial keel, bearing large, but not prominent, nodes at intervals of about 0.8 mm. Entire obverse face between the zoœcia apertures very finely striated. Lateral branches short, at their origin about three-fourths as wide as the midrib, tapering rapidly toward their rounded distal extremities; opposite or alternating, with eleven on each side in 1 cm., given off at an angle of from 60° to 80°. Zoœcia in two alternating ranges. Apertures sub-circular, with a very thin and slightly elevated peristome, about 0.1 mm. in diameter, and 0.35 mm. apart; eleven in 5 mm. They are arranged so that one is opposite a lateral branch and one between.

This species, though closely allied to several English and Scottish species, is nevertheless quite distinct. Of American forms *P. vinei* seems to be closer than any other, but differs in being smaller and in having three zoœcia where this has two.

The specific name is given in honor of Mr. John Young, of Scotland, who, chiefly in conjunction with Dr. Young, has done so much to bring out the minute details of structure of their Carboniferous Bryozoa.

Position and locality: Keokuk group, King's Mountain, Ky., and Keokuk, Iowa; also in the Cuyahoga shales of Ohio.

PINNATOPORA VINEI Ulrich.

Pl. LXVI, fig. 5-5b.

Zoarium pinnate; midrib slender, usually straight, 0.4 to 0.45 mm. wide, with the reverse side evenly rounded and finely striated. Obverse face low ridge-shaped, the mesial carina rounded, not prominent, with rather strong nodes at irregular intervals. Lateral branches from one to two mm. in length, like the midrib but only two-thirds as wide, oppositely or sub-alternately given off from the sides of the midrib; nine or ten in 1 cm. Zoœcial apertures in two alternating ranges, fifteen in 5 mm., subcircular, with faintly elevated thin peristome, about 0.1 mm. in diameter. All the interspaces between the apertures very finely striated longitudinally.

The thinner midrib, longer lateral branches, and shorter zoœcia, distinguish this species from *P. youngi* with which it is associated.

Named as a slight token of my appreciation of the labors of Mr. G. R. Vine on the Bryozoa of Great Britain.

Position and locality: Keokuk group, King's Mountain, Ky., Keokuk, Iowa, and in the Cuyahoga shales at several localities in Ohio.

PINNATOPORA FLEXUOSA Ulrich.

Pl. LXVI, fig. 4-4c.

Zoarium pinnate, midrib 0.5 to 0.6 mm. wide, branchlets 0.3 to 0.4 mm. wide, and, when entire, about 2.5 mm. long. Entire obverse face, between the zoœcia apertures, marked with strong flexuous striæ, those along the center of the branches a little the strongest. An occasional tubercle present. On the reverse both midrib and branchlets are rounded and finely striated longitudinally. Near the junction of the latter with the midrib, a small circular pore is often found. Lateral branches sub-alternating, comparatively remote, averaging five on each side in 1 cm., directed more or less distally. Zoœcia apertures in two alternating ranges, between ten and eleven in 5 mm., circular about 0.12 mm. in diameter, with well developed peristome.

This species is easily recognized by the rather remote lateral branches, the non-development of a carina, and, particularly, by the strong flexuous striations on the obverse side. The peristomes too are stronger and more elevated than usual.

Position and locality: Keokuk group, King's Mountain, Ky.

PINNATOPORA STRIATA Ulrich.

Pl. LXVI, fig. 4d.

Zoarium pinnate; midrib 0.5 to 0.7 mm. wide; branchlets from 1 to 2 mm. long, 0.3 to 0.4 mm. wide, directed somewhat distally, and fully as much toward the obverse side. Reverse of midrib with rather coarse, unequal, longitudinal striæ. Lateral branches opposite or alternating on the two sides of the midrib, with an average of nearly seven on each side in 1 cm.

Primary portion of zoœcia as well as their apertures in two alternating ranges, eleven or twelve in 5 mm., the ranges separated by a well developed and faintly nodulose keel. Apertures circular, widely sparated longitudinally, about 0.1 mm. in diameter. Hemisepta well developed.

The specimen from which the above description is drawn shows only the reverse, and was at first supposed to belong to *P. flexuosa*. The more strongly striated reverse, and more numerous pinnæ, led me to make another examination. Thin sections were prepared and these proved conclusively that it belonged to a very different species, having a marked carina and the primitive portion of the zoœcia in both the branchlets and midrib in two ranges. *P. flexuosa*, as may be seen on Pl. LXVI, fig. 4a, has the zoœcia of the branchlets practically in one range. *P. vinei* has shorter zoœcia and a greater number of branches, while in *P. youngi* the latter are shorter and more numerous.

Position and locality: Keokuk group; Bentonsport, Iowa.

PINNATOPORA CONFERTA Ulrich.

Pl. LVI, fig. 5, and Pl. LXVI, fig. 6.

Zoarium pinnate; midrib about 0.7 mm. wide, finely striate on the reverse, with the carina on the obverse face elevated, rounded, and, when perfect, bearing prominent nodes 1 mm. or less apart. Lateral branches also carinate, with somewhat closer nodes, 1.5 mm. long, about two-thirds as wide as the midrib, of the same width throughout, separated by interspaces very little wider than themselves, almost opposite on the two sides, ten in 1 cm., given off at an angle of about 60°. Apertures rather large, circular or slightly oval, 0.15 mm. in diameter, with very faint peristome, about their own diameter apart, with fifteen in 5 mm.

The distinctive features of this species are the large zoœcia apertures and the strong and closely arranged lateral branchlets.

Position and locality: Keokuk group, Keokuk, Iowa and Jersey Co., Ill. (Otter Creek).

PINNATOPORA TENUIRAMOSA Ulrich,

Pl. LXVI, fig. 7.

Of this species only the reverse aspect has been observed. The best fragment seen preserves a portion of the primary branch about 1 cm. long. This is about 0.6 or 0.7 mm. wide, and on one side throws off three, on the other only one secondary branch, varying in width from 0.5 to 0.6 mm. The primary and secondary lateral branches or pinnæ, diverge at angles of from 70° to 80°, are slender, about one-third as wide as the principal branches, from less than 1 to nearly 3 mm. long, those proceeding from the primary branch the longest, with twelve or thirteen given off on each side in the space of 1 cm. Surface of both branches and pinnæ marked with fine but distinct longitudinal striæ.

The characters relied upon in distinguishing this species are (1) the number and comparative slenderness of the pinnæ, and (2) the great length of those that proceed from the sides of the primary branch.

Position and locality: Waverly group, near Richfield, Ohio.

PINNATOPORA BELLULA Ulrich.

Pl. LXVI, fig. 8-8b.

Zoarium a very slender, small, pinnate frond. Midrib between 0.2 and 0.3 mm. wide, throwing off subalternately from the two sides, at an angle of about 50°, the pinnæ, which have a width of about 0.18 mm., and a length varying between 0.5 and 1 mm. Five pinnæ on each side in 5 mm. Reverse side rounded, granulose, the granules arranged in parallel longitudinal series on fine elevated lines. Obverse face subangular or rounded, without carina, but marked with flexuous striæ, strongest near the center of the midribs, where also a row of small and widely separated (0.8 mm.) nodes may be observed. Zoœcia in one range in both midrib and pinnæ. Apertures in two alternating ranges, with about twelve in each in 5 mm., circular, 0.1 mm. in diameter, surrounded by well developed peristome. They are so arranged that one is always opposite a pinna, and one in the space between.

This species is closely allied to the *P. flexicarinata* (Y. & Y. sp.) from the Carboniferous shales of Scotland. A comparison with authentic examples of that species shows that the Scotch form has six pinnæ to 5 in this; and fourteen cell apertures to twelve in *P. bellula*. The carina, nodes, and granulose striæ of the reverse are also all stronger than in the Illinois form. The *P. whitei* Foerste, from an equivalent horizon in Ohio, differs chiefly in having seventeen cell apertures where *P. bellula* has only twelve.

Position and locality: Base of Coal Measures; Seville, Ill.

PINNATOPORA TRILINEATA Meek.

Pl. LXVI, fig. 6.

Glauconome trilineata Meek, 1872. Pal. East Neb. p. 157. Pl. 7, fig. 4a? 4b–4d.

Zoarium a pinnate frond, the primary midrib 0.45 to 0.6 mm. wide, giving off long secondary lateral midribs, 0.35 to 0.45 mm. wide, at intervals of 3 mm. or more. Pinnæ 1.5 to 2 mm. long, 0.3 mm. wide, nearly opposite, twelve on each side in 1 cm. Reverse face strongly rounded, distinctly marked with longitudinal striæ, those on the pinnæ finer than those on the midribs. Obverse face of midribs subangular, with three, fine, straight lines along the center, the median one slightly the strongest. Pinnæ similarly marked but on a smaller scale. Zoœcia and their apertures in two ranges in both midrib and pinnæ. Apertures circular, 0.09 mm. in diameter, about twice as far apart longitudinally, with seventeen in 5 mm.; so arranged that one occurs opposite the upper half of the base of each pinna, and two in the space between. When in a good state of preservation they are surrounded by a thin and sharply elevated peristome. Of internal characters the strong development of hemisepta is the most noteworthy.

The three mesial lines constitute the principal external peculiarity of this species.

According to Meek's measurements, between eight and nine pinnæ are given off on each side in 1 cm. I have examined perhaps one-hundred fragments and all give twelve in that space.

The specimen represented by Meek's fig. 4a (*loc. cit.*), from which his measurements were evidently derived, has much longer pinnæ than any yet seen by me, and I doubt very much that it is the same species. It is attached to the matrix so that the reverse side only could be seen. Figures 4c and 4d, representing the obverse side, agree with my own observations in all respects excepting that the pinnæ are too thin. Possibly a young example was selected. In any event, it does not seem probable that the Upper Coal Measures of Nebraska contain two trilineate species.

Position and locality: One of the most characteristic species of the Upper Coal Measures. Examples are abundant at localities in Sangamon County, Ill. The original specimens are from Nebraska City, Nebraska.

PTILOPORA McCoy, 1844.

(Syn. Carboniferous Foss. Ireland, p. 200.)

(For generic diagnosis see page 398.)

I have been in doubt whether this genus presented closer relationship to the FENESTELLIDÆ or ACANTHOCLADIIDÆ. After much thought I have concluded that the pinnate form of growth must outweigh the dissepiments, the former being the result of peculiarities in zoœcial development, while the latter seem to indicate nothing beyond an economical manner of giving solidity and strength to the zoarium. It is true, of course, that in such a species as *P. paupera* we see resemblance to some Fenestellids, but on the other hand, *P. valida* and *P. cylindracea*, while possessing all the essential characters of *Ptilopora*, so closely resemble *Pinnatopora*, that a greater than generic separation is out of the question.

True species of the genus are first met with in the Hamilton group, one is known from the Burlington limestone, three or four from the Keokuk, and one, possibly two, from the Warsaw and St. Louis beds.

PTILOPORA ACUTA Ulrich.

Pl. LXV, Fig. 4-4a.

Zoarium a large pinnate frond, the largest fragment seen having a width of 3 cm. from the central shaft to the lateral margin.

Reverse. Mid rib strong, from 1.0 to 1.5 mm. in width, appearing like a cylindrical stem lying on the surface of the frond, and marked with distinct longitudinal striæ. Branches rather slender, generally a little flexuous, springing from the shaft, eight or nine in 1 cm., at angles varying in different examples from 22° to 42°. As in the specimen figured the angle may be quite different on the two sides of the shaft. Still, 30° seems to be about the normal. The average width of the branches is about 0.3 mm., but in extreme cases it may vary from 0.2 to 0.5 mm. Measuring at right angles to their direction, from thirteen to fifteen branches occur in 1 cm. Dissepiments slightly depressed, on a level with the branches, or somewhat elevated above them, usually a little wider than the branches, but varying in width from 0.3 to 0.7 mm. Surface of branches and dissepiments finely striated. Fenestrules long-oval, about 1.3 by 0.5 mm., with six in 1 cm.

Obverse face not well shown by any of the material before me, but, so far as can be determined, shows, that the midrib has a strong, rounded and striated keel, two ranges of zoœcia, with large apertures separated by a space about equal to their diameter, and that there are fourteen apertures in 5 mm.

The larger frond, more rounded midrib, and more acute angle at which the branches and midrib meet, distinguish this species from the associated *P. valida.* The Warsaw and St. Louis *P. prouti* has much shorter fenestrules, and closer and less acutely arranged branches.

Position and locality: The types are from the Keokuk group at Bentonsport and Keokuk, Iowa, but what seems to be the same species is represented in the Illinois State Museum by a specimen from the Burlington limestone, at Burlington, Iowa.

PTILOPORA VALIDA Ulrich.

Pl. LXV, figs. 5-5c, Pl. LXVI, figs. 1-1b.

Zoarium a narrow, pinnated frond, the entire width not known to exceed 1.5 cm., often closely resembling a robust *Pinnatopora*.

Reverse. Midrib comparatively strong, convex, 0.7 to 1.3 mm. wide, and like the branches finely striated longitudinally. Branches comparatively short, rather rigid, 0.4 to 0.5 mm. wide, given off from the midrib at an angle of about 55°, averaging ten on each side in 1 cm. At long intervals one of the branches grows stronger than the rest, and forms a new midrib, with branches like the primary one. Dissepiments depressed, thin, generally about 0.2 mm. wide, rarely more than three between any pair of branches. Fenestrules oblong subquadrate or oval, with average dimensions of 1.3 by 0.5 mm.; three occupy a space nearly 5 mm. long.

Obverse. Midrib with a strong rounded carina, carrying small nodes about 2 mm. apart. Branches subcarinate, also with small but more closely arranged nodes. Zoœcia in two ranges on both midrib and branches. Apertures rather large, fourteen on the midrib and sixteen on the branches in 5 mm., their diameter or less apart. With age, the midrib thickens and the apertures are covered by a finely striated deposit. Often, too, the branches are broken away, when the fossil presents an appearance that at first sight is quite puzzling and liable to cause mistakes.

The narrow fronds and thin dissepiments separate this species from *P. acuta.*

Position and locality: Keokuk group, Bentonsport and Keokuk, Iowa, and Jersey Co., Ill.

PTILOPORA CYLINDRACEA Ulrich.

Pl. LXVI, fig. 2–2b.

Zoarium when complete a narrow pinnate frond, with the branches extending about 5 mm. on each side of the midrib. Usually the branches are all broken away so that the zoarium looks like a slender rod with two ranges of small cells, and two more widely separated large openings beneath them. The latter represent the broken branches.

Reverse. Midrib prominent, subcylindrical, from 0.6 to 0.8 mm. wide, and like the branches finely striated. Branches subcylindrical, rigid, 0.3 to 0.4 mm. wide, twelve to fourteen given off from the midrib, at an angle of about 65° in 1 cm. Dissepiments easily overlooked, depressed, very thin, two or three in number, about 1.1 mm. apart. Fenestrules narrower than the branches.

Obverse. Midrib with a more or less defined, low, rounded, central ridge, carrying a row of small hollow nodes, 0.4 mm. apart, and, in the younger stages, with a fine line on each side. In old examples the whole space between the ranges of apertures is almost uniformly rounded, but without obliterating the nodes. The surface of the branches is simple rounded, but a similar row of small nodes runs along the center. Zoœcia in two ranges. Apertures submarginal, very small, circular or suboval, with prominent but not abruptly elevated peristome, thirteen or fourteen in 5 mm. on both midrib and branches. On the former they are situated one at the base of each branch and one midway between.

When found in shale, the substance of the zoarium has a polished aspect that is not shared by any of the associated Bryozoa.

This species, like *P. valida*, might easily be mistaken for *Pinnatopora*, and, indeed, I believe that the short branches and thin dissepiments of these two forms, point to a clear relationship with species of that genus.

Position and locality: Keokuk group, King's Mountain, Ky., and Bentonsport, Iowa. The examples from the last locality have the branches slightly wider apart than the Kentucky specimens. The last being the most perfect and numerous, are considered as the most typical.

PTILOPORA PAUPERA Ulrich.

Pl. LXVI, Fig. 10.

Zoarium a small, rather irregularly pinnate frond, with the hight and width about equal. Midrib and branches strong and much thickened near the base, rapidly tapering upward. In the upper half of the frond the midrib is usually less than one-third stronger than the branches, the latter being about 0.3 mm. wide. Here the branches are lax, flexuous, and bifurcate rather frequently, a feature of very unusual occurrence among species of the genus.

Reverse. Branches and midrib moderately convex and finely striated. Midrib slightly flexuous, tapering upward, giving off on each side about nine branches, at an angle of near 45°, in 1 cm. Branches connected by slender dissepiments forming comparatively large irregular fenestrules, of which about four follow each other in 5 mm.

Obverse. Midrib and branches subcarinate, the rounded keel, over the basal half of the zoarium, with closely arranged small nodes. Over the outer half the keel is somewhat sharper, the nodes less distinct, and, perhaps, wanting. Zoœcia apertures sub-oval, in two ranges, about their diameter apart, sixteen or seventeen in 5 mm.; with moderate peristome.

The characters of the basal portion of the frond mentioned in the above description have been derived from the central specimen of fig. 10. It is possible that this specimen may not belong to the same species as the other two represented in the figure. It shows the obverse side, but most of the zoœcia apertures are closed by a striated deposit, so that I could not satisfy myself in determining their number in a given space. The few that can be seen appear larger than in the true types, and I estimate that there are not more than thirteen or fourteen in 5 mm.

The small size and lax growth of the zoarium distinguish the species from all others known to me.

Position and locality: Keokuk group, King's Mountain, Ky.

PTILOPORA PROUTI Hall.

Pl. LXV, fig. 3-3c.

Ptilopora prouti Hall, 1858. Pal. Iowa, p. 653, Pl. 22, figs. 6a-6c, 7.

Zoarium a pinnate frond, attaining a height of 6 or 7 cm., and a width of 5 or 6 cm. Midrib rather strong, commonly about 1 mm. wide, giving off on each side about eleven or twelve branches, at the angle of about 50°, in 1 cm. Branches somewhat flexuous, averaging 0.4 mm. wide, but varying between 0.3 and 0.7 mm., the last just before bifurcating. Bifurcations rare, occasionally met with near the midrib, but usually occurring only in the outer half of the expansion. Zoœcia in two ranges on both midrib and branches, increasing to three before bifurcation takes place.

Reverse. Midrib prominent, sub-cylindrical, finely striated. Branches commonly a little flexuous, but sometimes quite rigid, striated, connected by depressed dissepiments two-thirds as wide as the branches. Fenestrules oval, about 0.5 by 0.3 mm., slightly longer in the outer portions of the frond, with nine or ten in 1 cm.

Obverse. Midrib with two narrow channels in which the zoœcia apertures are situated, and, between them, a strongly convex and striated carina, bearing large nodes at intervals of 1 mm. Branches sub-carinate, also with nodes but with them closer together. Zoœcia apertures circular, a little more than their diameter apart, with fifteen in 5 mm. on the midrib, and seventeen in the same space on the branches. Those of the branches have distinct peristomes, most elevated on the outer side.

The compact appearance of the zoarium, caused by the comparative strength of the branches and midrib, and the small fenestrules, serves to distinguish this species at a glance from *P. acuta.*

Position and locality; Warsaw beds, Warsaw, Ill., and Monroe Co., Ill., and near New Providence, Ind. Also in the lower beds of the St. Louis group at Barrett's Station, Mo.

SEPTOPORA Prout, 1859.

Trans. St. Louis Acad. Nat. Sci. Vol. 1, p. 448.

(For generic diagnosis see page 397.)

This genus includes some very interesting but, at the same time, exceedingly difficult forms. They required much study, and had I not had an abundance of good material to work upon, the following classification into species and varieties would have been nearly impossible.

The various species here defined may be divided into two groups; the first, comprising *S. cestriensis, S. subquadrans,* and

S. decipiens, having the number of branches increase mainly by bifurcation; the second, containg *S. biserialis*, *S. biserialis var. nervata*, *S. pinnata*, *S. robusta*, *S. robusta var. intermedia*, and *S. delicatula*, having the number increase entirely by interpolation. The first group is, so far as known, only represented in the Chester group, while the second, though occasionally met with in those beds, is almost restricted to the Upper and Lower Coal Measures. The discovery of this fact aided greatly in the separation of the species.

The position of the genus is between *Pinnatopora* Vine and *Synocladia* King. Both Meek and Swallow regarded *S. biserialis* as a species of *Synocladia*, but that they were in error is now generally admitted. *S. virgulacea* King, the type of that genus, has from three to five ranges of zoœcia, and, so far as known, is without the small accessory pores which are so characteristic of all the species of *Septopora.* The relations to *Pinnatopora*, though very evident, have not heretofore been pointed out. Take for instance *S. decipiens*, and we find upon comparison with species of *Pinnatopora*, that the only important character not common to them are the accessory pores. The importance of even this distinction is diminished by the discovery of similar pores on the reverse of *Pinnatopora flexuosa*. All the remaining species of *Septopora* form a fenestrated expansion by the union of the pinnæ of neighboring branches. The appearance of the ordinary zoarium of the two genera is, therefore, quite different, but, here again, *P. sedgwicki* Shrubsole, lessens the utility of the difference, being likewise possessed of a fenestrated zoarium. Certain differences in the internal structure of species of these two genera may be noticed in comparing the figures on Pl. LVI. *S. robusta*, in having three ranges of zoœcia on the pinnæ, or as they are usually called, the poriferous dissepiments, approaches *Acanthocladia* and *Synocladia*, two genera that hold the same relations to each other as *Pinnatopora* and *Septopora*.

SEPTOPORA CESTRIENSIS Prout.

Pl. LXIV, fig. 1-1*b*.

Septopora cestriensis Prout. 1859. Trans. St. Louis, Acad. Sci. Vol. I. p. 448, Pl. 18, figs. 2-2*b* (pars).

(Not *Septopora cestriensis* Meek & Worthen, 1870. Geol. Surv. Ill. vol. V, Pl. 24, fig. 14*a*-14*c*.)

Zoarium a rather delicate but compactly woven flabellate expansion. Branches not very rigid, averaging from twelve to fourteen in 1 cm., increasing in number by bifurcation and not by interpolation, with an average width of 0.5 mm., but enlarging from 0.3 or 0.4 mm. immediately after bifurcation to 0.7 or 0.8 mm. before the next division.

Reverse. Branches narrowly rounded, slightly zigzag or straight, striated when young and smooth on mature or old examples; accessory pores rather large, about 0.09 mm. in diameter, not very numerous, situated generally opposite the connecting branchlets or dissepiments. The latter are generally a little thinner than the branches and on the same level with them. Fenestrules varying in shape from circular or oval to sub-quadrate, commonly between ten and eleven in 1 cm.; but some otherwise typical specimens have twelve or thirteen in that space.

Obverse. Branches sub-angular, with a faint mesial keel, which is most prominent on worn examples; generally the keel expands at intervals of 1 mm. or less into rather prominent elongated nodes. The dissepiments extend directly across from branch to branch, and expand at their junction with them, causing rounded fenestrules to prevail. Near the outer margin of the frond the fenestrules are likely to be sub-quadrate. Zoœcia in two ranges, but a third is occasionally interpolated just before a bifurcation. Apertures circular, 0.14 mm. in diameter, about two-thirds of their diameter apart, twenty-two or twenty-three in 5 mm. Peristome thin and but little elevated. On the dissepiments the rule is to find four apertures, two on each side. Often, however, a fifth will occupy the central point, while at other times the number is reduced to three or even two. A small number of the accessory pores occur among the zoœcia apertures, but on this side they are usually restricted to the dissepiments.

The distinguishing features of this species are, the compact appearance of the net-work, the small rounded fenestrules, large number of branches in a given space, the short dissepiments and few zoœcia on them, and the comparatively large size of the accessory pores. These differences apply particularly to its nearest relative and associate *S. subquadrans*.

In the above I have restricted *S. cestriensis* to the small round meshed form, that was used by Prout when he illustrated his species, and which is particularly characteristic of the beds at Chester, Ill. The larger, or better, the less compact form which he, and Meek and Worthen after him, considered the same, can and ought to be separated.

Position and locality: Lower and middle beds of the Chester group. Not uncommon at Chester, Ill. Rather rare at Sloan's Valley and several localities in western Kentucky.

Septopora subquadrans Ulrich.

Pl. LVI, fig. 7, 8, and Pl. LXIV, figs. 2, 2b.

Septopora cestriensis M. & W. 1870. Geol. Surv. Ill. vol. 5, pl. 24, figs. 14*a*–14*c*.

Zoarium a large, flabelliform, undulating or flat net-work, consisting of approximately equal radiating branches, united by somewhat thinner, and more or less arched dissepiments, leaving transversely elongated fenestrules varying in form from subquadrate to irregularly crescentic. Branches increasing by bifurcation, averaging 0.5 mm. in width, and about ten in 1 cm., but extremes like seven and twelve in 1 cm., have been noticed. Fenestrules averaging 0.7 mm. wide by 0.5 mm. long, and varying between ten and one-half and twelve in 1 cm. Keel rounded, moderately prominent, with strong tubercles at intervals of 0.7 mm. Zoœcia in two ranges, with from four to twelve, normally, six to eight on the dissepiments, and twenty-one in 5 mm. in each range on the branches. Apertures circular, with faint peristome, somewhat less than their diameter apart. Accessory pores small, distributed irregularly among the zoœcia and on the reverse side of the branches. Fig. 2b shows their usual position and number. When in a good state of preservation they are elevated, sometimes to such an extent that the reverse side of the frond appears quite rough. Reverse finely striated on young examples, but near the base the striæ are always obsolete. On this side the branches appear rather rigid, and project more or less above the plane of the dissepiments.

The above briefly describes the principal characters of this variable species. For comparisons between it and *S. cestriensis* see description of that form. Compared with *S. biserialis*, the main difference will be found in the mode of increase in the number of branches, the method in this species being by bifurcation, while in the Coal Measure form the new branches are interpolated, *i. e.*, developed from the dissepiments or from the side of an older branch. The difference in this respect is fairly shown in two figures published by Meek and Worthen in vol. V, Pl. 24, of this series of reports.

Position and locality: Upper limestones of the Chester group. Abundant at Sloan's Valley, and other localities in Kentucky; less common at several localities in Illinois.

SEPTOPORA DECIPIENS Ulrich.

Pl. LXVII, fig. 9.

Zoarium a narrow pinnate stipe, dividing dichotomously at distant intervals, with often a fenestration for a short distance above the bifurcation. In one instance, the lateral branches have grown to be about 2 mm. long, and are connected by a celluliferous dissepiment, situated 1.2 mm. from the midrib or branch. Usually the pinnæ are short, sub-carinate, taper rapidly, with twelve or thirteen on each side in 1 cm. Midrib increasing gradually in width from 0.5 to 0.9 or 1.0 mm. between bifurcations; on the obverse with a well defined rounded carina, carrying faint nodes 1 mm. apart. Zoœcia in two ranges except often just beneath a bifurcation where three rows may prevail for a short distance. Apertures rather large, suboval, 0.15 mm. long, as much or less apart, seventeen in 5 mm. Peristome very faint. Accessory pores small, about 0.5 mm. in diameter, distributed at irregular intervals among the zoœcia apertures. Reverse of midrib rather broadly rounded, very finely striated, with a small number of accessory pores. The latter are easily overlooked. The enlarged view of the obverse face given on

Pl. 66, is faulty in having the cell apertures too small, and in not showing any accessory pores. The latter were first detected after the plates had been printed.

The isolation of the branches and consequent resemblance to *Pinnatopora*, distinguish this species from *S. subquadrans*. The zoœcia are also slightly larger. Fragments of similar appearance, but apparently belonging to a distinct species, have been noticed. One of them is represented by fig. 9a, on Pl. 66. This agrees very closely in its minute features with *S. subquadrans*, and may represent a variety of that species.

Position and locality: Chester group, Sloan's Valley, Ky.

SEPTOPORA BISERIALIS Swallow.

Pl. LVI, fig. 11.

Synocladia virgulacea? Swallow, 1858. Trans. St. Louis Acad. Sci. vol. 1, p. 179.
Synocladia biserialis Swallow, 1858. Trans. St. Louis Acad. Sci. vol. 1, p. 179.
Synocladia biserialis Meek, 1872. Pal. E. Neb. p. 156, pl. 7, fig. 5a–5e.
Synocladia biserialis Meek, 1874. Am. Jour. Sci. and Arts. p. 486.
Synocladia biserialis Meek, 1875. Pal. Ohio, vol. 2, p. 326, Pl. 20, fig. 5-5b.
Synocladia biserialis White, 1877. Wheeler U. S. Geol. Surv. vol. 4, p. 107, Pl. 7, fig. 3a–3c.

Zoarium large, irregular, infundibuliform, strongly folded and often overlapping in the upper portions, consisting of approximately equal, parallel radiating branches, their number increasing by lateral divisions, or intercalation of new branches, the whole being united into a fenestrated frond by the union of the lateral branchlets or pinnæ, which form more or less arched dissepiments. Fenestrules usually transversely oblong, often irregularly quadrangular or somewhat crescentic, wider than the branches, about thirteen in 1 cm. Branches averaging 0.5 mm. wide, but varying from 0.3 or 0.4 to 0.7 or 0.8 mm., with nearly uniformly ten in 1 cm.; reverse evenly rounded, with fine minutely granulose striæ, and a variable though never large number of accessory pores, chiefly occurring on the sides of the branches; their mouths are circular, about 0.07 mm. in diameter, and, when perfect, with a slightly elevated rim. The dissepiments are about two-thirds as wide as the branches, and, on the reverse side, more or less depressed below them, and striated. On the obverse face the branches and dissepiments present two ranges of rather large, sub-circular zoœcia apertures, separated by a thin mesial ridge, which is stronger on the branches than on the dissepiments, and carries a series of elongate, more or less prominent nodes, 0.8 mm. or less apart. Zoœcia apertures 0.13 mm. in diameter, about two-thirds their diameter apart, with twenty or twenty-one in 5 mm.; and from three to eight on each dissepiment; when well preserved with a thin but distinct peristome. Irregularly distributed between the apertures, especially on the dissepiments, there are accessory pores of the same nature and size as those on the reverse side of the zoarium.

The measurements of this species agree very closely with those of *S. subquadrans*, but there are, nevertheless, certain differences that show them to be distinct. In the Chester form the branches increase by true bifurcation, while in *S. biserialis* the mode is by lateral division and interpolation. Another difference will be noticed upon comparing figs. 7 and 8 with fig. 11 on Pl. LVI. These represent the appearance of the two species in thin sections, and show a minute dotted character of the dense reverse layer and the zoœcia interspaces in the Carboniferous species that is entirely absent in *S. subquadrans*. The ultimate form of the zoarium also shows some differences, the latter being characterized by its slightly undulated flabellate form, while *S. biserialis* forms a strongly folded infundibuliform zoarium. On the whole, therefore, I believe the specific separation is justified.

Position and locality: Upper and Lower Coal Measures, at localities in Illinois, Iowa, Kansas, Nebraska, Missouri, and Kentucky.

SEPTOPORA BISERIALIS VAR. NERVATA Ulrich.

Pl. LXIV, fig. 6.

This designation I propose provisionally for a form represented in the collections before me by seven examples. They differ from the typical form of the species in having primary and secondary branches, the former being much stronger than the latter, and arranged in a radial manner around the base. The secondary branches are thinner, nearly parallel with each other, and given off from one or both sides of the primary set at a very acute angle. At intervals one of the secondary branches becomes thickened and is likewise pinnated. The fenestrules are sub-quadrate or ovate, generally a little wider than the branches, with eight or nine in 1 cm. in six of the specimens, and between ten and eleven in the seventh. In other respects the variety agrees with the typical form.

Three of the specimens are from the Chester group of Kentucky, three from the Upper Coal Measures of Illinois, and one from the same horizon near Red Oak, Iowa.

SEPTOPORA PINNATA Ulrich.

Pl. LXIV, fig. 7. Pl. LXV, figs, 1-1a.

This form agrees in many respects with *S. biserialis*, but the pinnate arrangement gives it such a different aspect that it seems unreasonable to regard them as specifically identical. Their relations are about the same as those of *S. decipiens* to *S. subquadrans*. In distinguishing it from the var. *nervata*, we find that the branchlets are given off at a much less acute angle, and that altogether the branches are thinner and the fenestrules comparatively larger. Eight branchlets, averaging 0.3 mm. wide, are given off from each side of the midribs, in 1 cm. The midribs vary from 0.5 to 0.7 mm. wide.

Position and locality: Upper Coal Measures, Jasper County, Illinois.

SEPTOPORA ROBUSTA Ulrich.

Pl. LVI, fig. 9-9c, and Pl. LXIV, figs. 3-3a.

The zoarium of this species is flabellate, and, though with many points of resemblance to *S. biserialis*, will be immediately distinguished by its more robust appearance, the branches having an average width of between 0.7 and 0.8 mm., the extremes being 0.6 and 1.1 mm; five to eight branches occur in 1 cm. The dissepiments are either direct or arched, strong, from 0.4 to 0.7 mm. wide, and somewhat depressed on the reverse side; the fenestrules vary from circular to transversely oblong subquadrate, usually wider than the branches, with seven or eight and rarely nine in 1 cm. longitudinally. The zoœcia form two ranges on the branches, with twenty-two or twenty-three in 5 mm., and three irregular rows on the dissepiments. The apertures are comparatively large, being 0.14 mm. in diameter, and separated by little more than half their diameter. One of the principal features of the species is the large number of the accessory pores on the reverse side. A few of these pores also occur among the zoœcia apertures.

Position and locality: Upper Coal Measures, Fayette County, Illinois.

SEPTOPORA ROBUSTA var. INTERMEDIA Ulrich.

Pl. LVI, fig. 10, and Pl. LXIV, figs. 4-4a.

Under this provisional name I desire to make known a form from the Chester limestone of Kentucky, that differs from the typical form in having more delicate branches, and longer and more arched dissepiments. The former vary in width between 0.4 and 0.7 mm., and the latter usually carry only two rows of zoœcia. There are three specimens, two from near Litchfield and one from Sloan's Valley. One preserves the base with a large number of rootlets.

SEPTOPORA DELICATULA Ulrich.

Pl. LXIV, fig. 5-5*a*.

Of this species only the reverse is known, but this is so characteristic that there is no danger of mistaking the species. The zoarium is small and exceedingly delicate. The branches are rather narrowly rounded, distinctly striated, and vary in width between 0.2 and and 0.4 mm. The intervals between them average 1.2 mm. Dissepiments or connecting pinnæ slender, about two-thirds as wide as the branches, and 1.2 to 1.5 mm. distant from each other. A few accessory pores are developed, usually at the base of the dissepiments.

Position and locality: Lower Coal Measures, Seville, Illinois. Associated with *Fenestella wortheni*, *F. sevillensis*, *Rhombopora multipora* (Foerste) and other species.

ACANTHOCLADIA King, 1850.

(Monograph Brit. Perm. Foss. p. 48.)

(For generic diagnosis see p. 398.)

On plate LVI figures 1 to 1c, illustrate the internal characters of *A. anceps* Schlotheim, the type of the genus. According to my observations, the zoœcia are arranged about as follows: In *A. anceps* there are generally four alternating rows of zoœcia on the main branch, but the number varies from three to six. Of these the two central ranges are the principal ones, since they run without interruption throughout the length of the stem, while the one or two rows on each side of them are often discontinuous. This fact argues a relationship to *Septopora* that is better shown in *A. fruticosa*, in which, though with ample room for them, the lateral rows are developed only along the line of junction with the lateral branches. In both species the lateral branches or pinnæ have three ranges of cells. Another feature common to both *Septopora* and *A. fruticosa* are the small accessory pores. I have, however, not detected them on the reverse side of the Permian species.

ACANTHOCLADIA FRUTICOSA Ulrich.

Pl. LXV, fig. 2-2c.

Zoarium strong, fruticose, pinnated, with the primary branch giving off similar pinnated branches at frequent but irregular intervals. Pinnæ short, varying in length, between 1 and 3 mm.; 0.6 to 0.9 mm. wide, tapering slightly, with the free ends obtuse. Primary branches from 1 to 1.5 mm. wide, giving off on each side, seven pinnæ or lateral branches in 1 cm.

Obverse face showing three, often irregular alternating rows of zoœcia apertures on the pinnæ, and two central rows on the midribs. The latter are situated in two deep furrows, with sixteen in 5 mm., and are generally flanked on one or both sides by an intermediate row which more properly belongs to the series that pass on into the pinnæ and lateral branches. Apertures circular, with no appreciable peristome, about 0.1 mm.

wide, and about one and a half times their diameter apart. On the ridges chiefly, will be found small accessory pores, about equal in number to the zoœcia.

Reverse face very finely striated, rather strongly rounded, with numerous accessory pores arranged in a line near the margins of the branches and pinnæ.

The shrubby appearance of the zoarium, the three ranges of zoœcia on the pinnæ, and the accessory pores, induced me to place this species with *Acanthocladia*, the greater persistence of the lateral rows of pores on the main stem of *A. anceps* being regarded as of only specific importance. I am not acquainted with any bryozoan in American Carboniferous rocks that could for a moment be confounded with *A. fruticosa*. What Swallow's *A. americana* may be, has not been determined, but his meagre description is nevertheless sufficient to show that it can not be the same as the present species.

Position and locality: Upper Coal Measures, near Springfield, Illinois.

DIPLOPORA Young and Young, 1875.

(Proc. Nat. Hist. Soc. Glasgow.)

(For generic diagnosis see page 398.)

The above name was proposed by the authors cited as a subgeneric division of *Glauconome* (*Pinnatopora*). They include under it only one species which they call *G.* (*Diplopora*) *marginalis*, and describe as having a pore beneath each zoœcia aperture. As I have already shown, this supposed suboral pore is the result of attrition whereby the convex front of the cell was partially worn away, leaving the superior hemiseptum to separate the "pore" from the aperture. As, however, the species is one of several deviating from *Pinnatopora* in wanting the pinnæ, I have concluded to adopt their name in a generic sense.

Beside *D. marginalis*, which is from the Scotch Carboniferous shales, I have met with three other species. One of these has lately been described from England, by Mr. Vine, as *Pinnatopora? simplex*; the remainder are from Illinois, one from the Lower Coal Measures, the other from the Chester. The latter is somewhat doubtful as it differs from the others in having its branches divided dichotomously.

DIPLOPORA BIFURCATA Ulrich.

Pl. LXII, fig. 12-12a.

Zoarium very small, consisting of slender sub-cylindrical dichotomizing branches, about 0.3 mm. in diameter, bifurcating at intervals of from 1 to 3 mm. Obverse side with two ranges of small, zoœcia apertures, situated along the margin to which their rather prominent peristomes give a slightly wavy outline. Apertures circular, about 0.08 mm. in diameter, twice their diameter apart, with twelve in 3 mm. Between the ranges of apertures the surface is rather narrowly rounded but not carinate, and occasionally exhibits a small tubercle. Reverse of branches finely striated.

It is not improbable that this species has closer affininities with such species of *Thamniscus* as *T. furcillatus*, which it resembles in the dichotomization of its branches; but, in the present state of our knowledge, the two ranges of zoœcia seem to demand recognition, and I have accordingly placed the species here.

Position and locality: Chester group, Chester, Illinois.

DIPLOPORA BISERIALIS Ulrich.

Pl. LXII, fig. 11-11c.

Zoarium consisting of very slender, sub-cylindrical, straight or slightly curved stems, nearly 0.3 mm. wide and somewhat less in thickness, which throw off, at variable but long intervals precisely similar lateral branches. Margins wavy, due to the projection of the zoœcia apertures. Reverse of branches finely striated, evenly rounded. Obverse, with two ranges of alternating zoœcia. Apertures subcircular, marginal, opening obliquely outward, with elevated peristome, about 0.1 mm. in diameter, once and a half to twice their diameter apart, with twenty in 5 mm. Surface between the ranges of apertures subangular, and marked with faint, intermittent, longitudinal striæ.

The Scotch *D. marginalis* Y. & Y., to which this species is closely allied, has a thin tuberculated central keel, and usually another on each side of it. The reverse is also granulo-striate.

Position and locality: Lower Coal Measures, Seville, Ill.

SPHRAGIOPORA Ulrich.

(For generic diagnosis, see page 398.)

Although externally somewhat resembling the isolated colonies of *Botryllopora* Nich., the species upon which this genus is founded proves upon investigation very different. That genus exhibits little to distinguish it from the FISTULIPORIDÆ, while *S. parasitica* in no feature reminds us of that family. Taking only the zoœcial characters into consideration the genus agrees very closely with both the FENESTELLIDÆ and ACANTHOCLADIIDÆ. The zoarium is however so very different that a reference to either one of those families seems out of the question.

SPHRAGIOPORA PARASITICA Ulrich.

Pl. LXV, fig. 6, 6*a*.

Zoarium a small disc-shaped body attached parasitically to foreign objects; very frequently the strong supports of *Lyropora*. Upper surface flat or a little concave; base smooth, forming a margin around the raised celluliferous portion. Diameter of zoarium, when mature, from 1 to 2 mm., height about 0.5 mm. The smallest specimen seen is 0.32 mm. in diameter. On a mature example the zoœcia apertures are arranged in an irregularly radial manner about the center, upon the summits of six to nine more or less elevated ridges. At first they form only single rows, but at the outer margin the arrangement is biserial. A cyclic arrangement is also more or less evident. Apertures subcircular, about 0.09 mm. in diameter, generally with a faint peristome, occasionally preserving rayed operculum-like covers. A variable number of irregularly distributed accessory pores and tubercles also present.

Position and locality: Chester group, Chester, Ill. What may prove another species occurs attached to shells in the Upper Coal Measures of Illinois. Its zoarium is comparatively higher, and its zoœcia apertures, so far as observed, not radially arranged.

PHYLLOPORINA Ulrich.

(For generic diagnosis see page 399.)

After extended study this genus was established for the reception of a well marked group of Silurian Bryozoa. Nicholson's *Retepora trentonensis*, and Hall's *R. asperatostriata* are regarded as the typical species. The earliest species known belong to the Chazy group from which horizon I figured one (Pl. LIII, fig. 4,) that is identified with Hall's *Gorgonia? aspera*. It is a peculiar form and differs widely from the ordinary species of *Phylloporina*, among which it is now placed with some doubt. The other species that should be removed to the new genus are *Retepora trentonensis* Nich., *Intricaria reticulata* Hall, *Phyllopora corticosa* Ulr. (Trenton): *Intricaria clathrata* M. & D., *Phyllopora variolata* Ulr. (Cin. gr.); *Retepora angulata* Hall, (Clinton); and *R. asperatostriata* Hall, (Niagara). Several new species are known, one of them (*P. dawsoni*) is briefly defined on page 331 and the internal structure very well illustrated on Pl. LIII.

PHYLLOPORINA GRANISTRIATA Ulrich.

Pl. XXIX, Fig. 3-3a.

Zoarium an undulated expansion, consisting of more than ordinarily rigid, slender branches, from 0.3 to 0.5 mm. in width, that inosculate at rather long but irregular intervals. Fenestrules narrow, with an average length of about four mm., but varying from two to six mm.; width from 0.2 to 0.7 mm. Reverse with fine, granulose, longitudinal striæ. Celluliferous side not seen. Zoœcia (as observed in sections) tubular, arranged in three rows. Apertures circular, with a small peristome, 0.09 mm. in diameter, ten or eleven in two mm. Rows of cells separated by slightly elevated carinæ, bearing one small acanthopore to each zoœcium.

This species is allied to *P. reticulata* Hall, and *P. dawsoni*. From the first it is distinguished by the stronger branches and much larger fenestrules. From the second by the same differences, and in having three instead of two rows of zoœcia. In the length and form of the fenestrules the species resembles *P. trentonensis* Nich., but they differ too obviously in other respects to require any further comparison

Position and locality: (?) Base of Cincinnati group, Alexander Co., Ill. Another specimen was collected by Prof. Moritz Fischer in the upper beds of the Trenton group at Lexington, Ky.

CHAINODICTYON Fœrste, 1887.

(Bull. Sci. Labor. Denison Univ., Vol. II, p. 81.)

(For generic diagnosis see page 399.)

This genus was founded upon a species from the Lower Coal Measures of Ohio. Its fenestrules and zoœcia apertures are slightly larger than those of the Illinois form, but in all other respects the two agree very closely. Both greatly resemble the *Retepora undata* McCoy, in having the reverse transversely undulated, and it is not improbable that a careful examination of McCoy's species will show it to be congeneric with the American types. The elongate, conical, or subtubular zoœcia, their large impressed apertures, and the thin interspaces, place the genus into the new family PHYLLOPORINIDÆ.

CHAINODICTYON LAXUM var. MINOR Ulrich.

Pl. LXII, fig. 3-3a.

Zoarium a reticulated foliar expansion, consisting of thin inosculating branches, united in such a manner that they leave irregular lozenge-shaped fenestrules averaging 1.5 mm. in length by 0.8 mm. in width. The fenestrules are ranged in moderately regular longitudinal and diagonally intersecting series, with respectively 4.5 and 6 to 7 in 1 cm. each way. Branches strongly convex on the obverse side, 0.3 to 0.45 mm. in width, with four alternating ranges of zoœcia. Apertures rather large, ovate-acuminate, somewhat oblique, arranged in acute diagonal series. On the reverse face the branches are marked with sub-imbricating transverse folds or striæ, which pass across the flattened surface of the branches in a curved direction.

This variety differs from the typical form of the species in having smaller, and more regularly arranged fenestrules. The zoœcia apertures also seem to have been somewhat smaller, but this point was not determined satisfactorily.

Position and locality: Lower Coal Measures, Seville, Ill.

ARTHROCLEMA Billings, 1862.

(Palæozoic Fossils, vol. I, p. 54.)

(For generic diagnosis see page 400.)

ARTHROCLEMA ANGULARE Ulrich.

Pl. XXIX, fig. 6, 6b.

Of this species I have seen only isolated segments, but there can be no question as to their generic relation. The primary segments are four mm. in length, about one mm. in diameter, somewhat irregularly cylindrical, with the ends slightly thickened, solid, the proximal extremity obtusely pointed, the upper only convex and faintly indented at the center. On two opposite sides of the segments there is a large and rather shallow socket, situated a little below the middle of the length. The secondary segments are six-sided, 5.5 mm. in length, 0.5 mm. or very little more in diameter. Zoœcia with narrow oval apertures, 0.07 mm. wide, 0.17 mm. long, seven in three mm. arranged in longitudinal series, between the strong bounding angles of the slightly concave sides of the segments. The lower margin of the apertures is more prominent than in front, and generally drawn out posteriorly. On the primary segment the zoœcia are less regularly arranged, and the interspaces between the apertures flexuously striate, especially in the vicinity of the articulating sockets. Tertiary segments not observed.

In most respects the above species agrees with *A. pulchellum* Billings, from the Trenton of Canada. Before me I have a number of very fine specimens of that species, showing that both the primary and secondary segments are longer in the Illinois species, those of the Canadian examples being quite constantly two or three mm. in length. The cells are also a little smaller and closer together, there being six in two mm.; the number in the length of a segment varying from four to seven, generally five or six. One specimen which I collected at another locality* is clearly distinct from Billings' species. This species I propose to call *A. billingsi*, in honor of the eminent founder of the genus. It is distinguished as follows:

The primary segments are 3.5 to 4 mm. in length, and 0.8 mm. in diameter. The first of each of the secondary segments is also about 4 mm. in length, while the remaining secondary, and all the tertiary joints, are only 2 mm. long by about 0.5 mm. in diameter. The most striking peculiarity is that each of the primary segments articulated with four secondary segments, two upon each side. Compared with *A. pulchellum* the cell apertures are more crowded and thin-walled, as well as sub-quadrate instead of oval, though also six in two mm. The whole zoarium also has a more rigid appearance than has been observed in any example of that species. (Pl. XXIX, fig. 6c.)

HELOPORA Hall, 1852.

(Pal. N. Y. Vol. II, p. 44.)

(For generic diagnosis see page 401.)

The typical species of this genus is Hall's *H. fragilis*, a very abundant and characteristic fossil of the Clinton group of Canada. Beside the type species, seven others are known to me that are constructed upon the same general plan,† four of them Lower Silurian and three Middle or Upper Silurian. The Lower Silurian species differ from the Upper Silurian and typical section of the genus, in having the cell apertures arranged in longitudinal series between elevated ridges, and the interspaces between the ends of the apertures longer. In *H. fragilis* the zoœcia apertures are oval or sub-quadrate, with rather thin equal walls. In *H. lindströmi*, n. sp., they are ovate, with hexagonal margins. The Lower Silurian species are also without the small acanthopores which are found in the Upper Silurian

*In the city of Ottawa, at the base of the bluffs near the ferry landing.

† In the Catalogue of Silurian Fossils of Anticosti, Mr. E. Billings describes twelve species, which he refers to *Helopora*. Upon examination only three of these prove congeneric with *H. fragilis*.

forms. When the various species now referred to the genus are better understood, these two sections will probably be separated generically. A suggestive resemblance to Cyclostomatous Bryozoa is represented by *H. imbricata* and *H. spiniformis*. The internal structure of two typical species is represented in the accompanying cut.

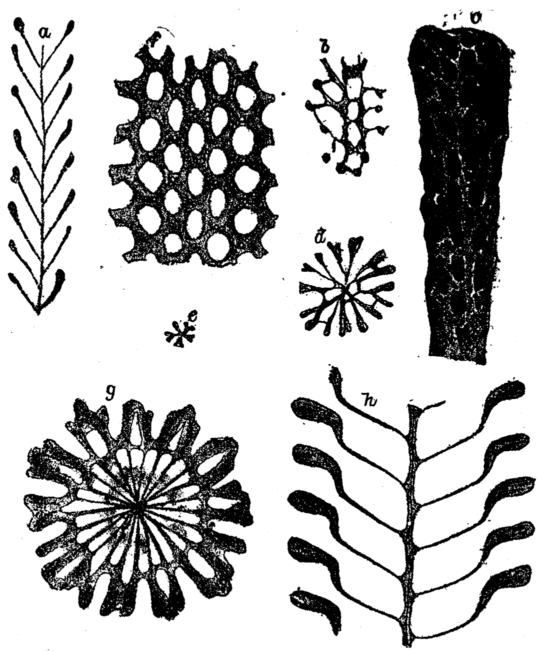

Fig. 18, a, b, c, d, e. Sections of *Helopora fragilis*, x18, Clinton group, Hamilton, Ontario. Fig. *a*, tangential section as it appears in the ferruginous matrix; in these examples the extreme outer region is destroyed; *b*, tangential section of another example, showing acanthopores at surface, etc.; *c*, transverse section near upper extremity of segments; *d*, same at base; *e*, vertical section.

Fig. *f*, *g*, *h*, sections of *Helopora lindströmi*, n. sp. x18. Upper Silurian, Gotland; *f*, tangential section showing form of zoœcia and acanthopores; *g*, transverse section; *h*, vertical section. The cylindrical or slightly club-shaped segments of this fine species vary in length from 10 to 15 mm., in diameter from 1.3 to 1.8 mm. Upper extremity flattened, slightly concave centrally; lower end moderately convex. Zoœcia arranged in quincunx; measuring lengthwise seventeen in 5 mm.; diagonally four in 1 mm. Apertures direct, oval, with a narrow peristome set into a rhomboidal or hexagonal concave space. Between the ends of the cells a strong acanthopore. It gives me great pleasure to propose the above name in honor of the talented Swedish Palæontologist, Dr. Gustav Lindström, to whose kindness I owe the opportunity of studying this beautiful species.

HELOPORA IMBRICATA Ulrich.

Pl. XXIX, Fig. 5.

Segments with a rough aspect, 3 or 4 mm. in length, and 0.5 mm. in diameter; upper end flattened, lower extremity obtusely pointed and striated. Zoœcia in seven or eight vertical series around the segment, the rows being separated by rather inconspicuous carinæ; also in much more conspicuous transverse series, on an average 0.3 mm. distant from each other. Apertures when worn, oblong quadrate; in the perfect state oblique, sub-circular or ovate, 0.1 mm. wide, with the lower margin strongly elevated and produced posteriorly into three small ridges, the central one terminating at or within the mouth of the preceding cell, is the most persistent, while the other two, which continue into its margin, are generally fainter and may be obsolete. The transvere approximation of the zoœcia and the prominence of the posterior margin impart a characteristic imbricating appearance to the segments.

This species resembles *H. spiniformis* Ulrich, from the base of the Trenton group of Tenn., but is distinguished by the shorter segments, more pronounced aperture margin, and the ridges between the ends of the cells.

Position and locality: Cincinnati group. Isolated segments are not uncommon on the surface of limestone slabs at Wilmington, Ill.

NEMATOPORA Ulrich.

(For generic diagnosis see page 401.)

The typical and earliest known species of this well marked and natural group of Palæozoic Bryozoa is the *N. quadrata*, n. sp.,* from the Trenton limestone of New York. The next

* The characters of this species are as follows: Zoarium slender, dichotomously branched at varying intervals; branches quadrangular, 0.3 or 0.4 mm. wide. Zoœcia arranged alternately in four longitudinal series, separated by a double ridge. Apertures oval, 0.4 mm. wide and nearly twice as long, four in 2 mm. lengthwise; surrounded by distinct peristome; peristomes connected longitudinally by a thin ridge. (Pl. XXIX, fig. 12.)

The double ridge between the ranges of cells is the most conspicuous peculiarity of this species. It is common on slabs from Trenton Falls, N. Y.

species occurs in the Alexander Co. beds of the Cincinnati group. (The exact age of these beds is somewhat doubtful, and I am inclined to regard them as more likely representing an upper member of the Trenton group). Four species are known and now described from the horizon. So far as known, the genus is represented only by an undescribed species in undoubted Cincinnati group deposits, but from the divisions of the Anticosti group, Billings describes five forms under *Helopora* that have the characteristic features of the genus. These are *H. concava, formosa, lineata, striatopora,* and *strigosa*. The *H. lineopora* may also belong here. Of Niagara species, Hall's *Trematopora minuta* and one or two undescribed species are congeneric with *N. quadrata*. As yet the genus is unknown above the Niagara formation.

Nematopora retrorsa Ulrich.

Pl. XXIX, fig. 9-9b.

Zoarium ramose, sub-cylindrical, branching irregularly, about 0.6 mm. in diameter. Zoœcia arranged in longitudinal series, about 5 in two mm., between eight to ten straight and moderately prominent ridges. Apertures sub-circular, 0.1 mm. in diameter, slightly truncated, and sloping on the posterior side; the anterior margin direct, sharp, sometimes with a perceptible rim. Immediately below the orifice the interspace exhibits three faint striæ. Walls of zoœcia very thin, appearing somewhat sickle-shaped in vertical section.

The backward direction and the subcircular form of the zoœcial apertures are characteristic features. In *N. fragilis* the apertures are also directed backwards, but they differ in being oval, while the longitudinal ridges are less distinct or absent, and the rows of zoœcia only six, instead of eight to ten.

Position and locality: Base of Cincinnati group. Alexander County, Illinois.

NEMATOPORA ALTERNATA Ulrich.

Pl. XXIX, fig. 8-8*a*.

In growth and general aspect this species closely resembles the preceding, and in the worn condition in which they are usually found, it is not easy to distinguish them. When in a good state of preservation, the alternate arrangement of the cells, absence of longitudinal separating carinæ, and other characters shown in the figure, will separate them.

Position and locality: Associated with the preceding.

NEMATOPORA FRAGILIS Ulrich.

Pl. XXIX, fig. 10-10c.

Zoarium ramose, very slender, branching dichotomously or otherwise; branches 0.35 mm. in diameter. Zoœcia in six longitudinal ranges, seven in four mm.; ranges not separated by a ridge, though the branch looks angular when worn. Apertures ovate, 0.08 mm. in width, twice as long and channeled posteriorly; a faint peristome around the sides and front margins. In vertical sections the walls are thin and falciform. Transverse section show two minute axial tubes at the center of the branch.

The six ranges of zoœcia suggest a comparison with *H. lineata* Billings (Pl. XXIX, fig. 7), from the Anticosti group, but we soon find that they disagree in nearly every other respect. The species finds closer allies in *N. retrorsa* and *N. alternata* but, when in a good state of preservation, the different form of aperture, smaller size of branches and other characters readily distinguish them.

Position and locality: Base of Cincinnati group; Alexander County, Illinois.

NEMATOPORA DELICATULA Ulrich.

Pl. XXIX, fig. 11-11b.

Zoarium small, exceedingly slender, ramose above the pointed basal end. Branches quadrangular, each side 0.15 to 0.18 mm.

wide. Zoœcia in four ranges, with subcircular or ovate aperture, 0.12 mm. in the largest diameter, separated by long intervals, about three in 0.2 mm. Peristome very faint, often confluent with the moderately sharp angles of the branches.

The exceeding delicacy, widely separated zoœcial apertures, and quadrangular zoarium of this species, distinguish it from all other species of the genus, excepting *N. quadrata*, known to me. It is too distinct from that form to require comparisons.

Position and locality: Associated with the preceding species in the Cincinnati group, Alexander County, Illinois.

RHOMBOPORA Meek, 1871.

(Pal. Eastern Nebraska.)

(*Orthopora* Hall. Pal. N. Y. Vol. VI, p. XIV.)

(For generic diagnosis see page 402.)

Of the Palæozoic genera of Bryozoa this genus ranks next in importance to *Fenestella* and *Polypora*, having a known representation in American rocks of no less than 46 species. These range through all the important divisions beginning with the Niagara, where we meet with one species (*Trematopora granulifera* Hall). In the Lower Helderberg we have three or four, in the Upper Helderberg and Hamilton ten to twelve, in the Lower Carboniferous divisions at least twenty-five, and in the Lower and Upper Coal Measures five. The general characters of the genus are maintained throughout with remarkable persistency, and I cannot mention a single feature, either external or internal, in which the Silurian and Devonian species, taken as a whole, differ from the Carboniferous forms. It is, therefore, a little surprising that Hall should propose *Orthopora* for the reception of the majority of the Upper Silurian and Devonian forms, since the ground is fully covered by *Rhombopora*. What is even more astonishing is that *Orthopora* is defined as a subgenus under *Trematopora* when the typical species of the two groups are not closely related in any respect, and really belong to different suborders. Even *Orthopora* as figured in Vol. VI, N. Y. Pal., contains widely divergent forms. *Acanthoclema* is the name proposed by the same authority for another group of closely related forms. The type species is marked by longitudinal ridges and a strong spine which is situated on the depressed space between the ends of the zoœcia apertures. *A. confluens*, of the present work, has these two essential features, but I very much fear that the division will prove of little value, as it will be exceedingly difficult to draw the line between it and *Rhombopora*. A second group embraced by Hall's *Acanthoclema* are widely different from his type species, and belong to my genus *Streblotrypa*. Of these I may mention *A. scutulatum* Hall, and *A. hamiltonense* Nicholson, sp.

RHOMBOPORA SUBANNULATA Ulrich.

Pl. XLV, fig. 1-1i.

Zoarium dendroidal, branching dichotomously at intervals of 15 mm. or more, and inclining to spread in the same plane. Branches from 1.2 to 2 mm. in diameter, marked with more or less noticeable annulations between 1.5 and 2 mm. apart. Zoœcia proceed obliquely out from the axis of the branch at an angle of about 45°, and have irregularly, flexuous thin walls. Two or three superior hemisepta and an occasional inferior hemiseptum are seen at the close of the immature region in vertical sections. The zoœcia walls are in contact. In young examples they are comparatively thin, the apertures sub-rhomboidal in shape and arranged in diagonal intersecting series winding spirally around the branch. Measuring diagonally ten in 2 mm. At each angle a small but distinct tubercle. As the zoarium matures, the apertures become smaller and subcircular or oval in shape, the interspaces thicker, multigranose, and occasionally form faint longitudinal ridges. Now there are nine apertures in 2 mm. diagonally.

In transverse and tangential sections the strong hemisepta cause appearances likely to be mistaken for diaphragms.

This species resembles several others but is clearly distinct. The superficial appearance, as shown in the figures, varies greatly according to the age of the examples. With the aid of tangential sections the extremes are brought together, showing what may also be seen by examining the opposite ends of large fragments, that they are really due to age. *R. varians*, of the Keokuk group, shows similar variations.

Positition and locality: Hamilton group, Buffalo, Iowa.

RHOMBOPORA SULCIFERA Ulrich.

Pl. XLV, Fig. 2-2b.

Zoarium consisting of slender cylindrical stems, 1 mm. or a little more in diameter, none of which were observed to branch, though probably doing so at long intervals. Zoœcia apertures oval, about 0.17 by 0.08 mm., arranged in diagonally intersecting series, crossing each other at an angle of about 90°, with eight or nine in 2 mm., measuring diagonally, and about six in the same space longitudinally. Interspaces as wide or wider than the apertures. A considerable number of small spines encircle the apertures, and are often arranged in a double series. In the latter case the center of the interspace is depressed, so that the apertures appear to be surrounded by a granulose peristome. The distinctness of this furrow, which has suggested the specific name, depends largely upon the preservation of the specimen. Beside the small spines, a less numerous series of larger size are present, generally one between the ends of the apertures. In tangential sections the small spines are noticed only in the extreme outer region of the zoarium, while the larger ones extend inward to a greater depth.

The smaller size of the branches, the depressed interspaces, and their great thickness in tangential sections, distinguish the species from *R. subannulata*.

Position and locality: Hamilton group; Davenport, Iowa. The specimens were presented to the author by Rev. W. H. Barris of Davenport. Iowa.

RHOMBOPORA LINEINODIS Ulrich.

Pl. XLV, Figs. 3-3b, and (?) 4-4a.

Zoarium consisting of slender stems from 0.5 to 0.8 mm. in diameter, branching dichotomously at intervals of from 3 to 6 mm. Surface appearing beaded from the large number of small spines arranged serially and close together on straight or flexuous, elevated, rounded ridges, running parallel with the length of the branches between the rows of apertures. In young examples these ridges are generally more flexuous than in the larger specimens. Apertures long oval, their longer diameter about 0.14 mm., the shorter 0.07 mm., alternating in the adjoining rows, with six in two mm. longitudinally, and about five in 1 mm. diagonally.

A variety of this form, or, perhaps, a closely related species, occurring with it, is represented by figs. 4 and 4a on Pl. XLV. Its zoarium has a stunted appearance, caused by the frequent bifurcation of the branches. The zoœcia apertures are shorter, and there are eight in 2 mm. longitudinally. The granules and ridges are less marked, and, especially near the base, many of the zoœcia apertures are closed by a thick calcareous deposit. Should these differences prove constant, the form might be called *R. humilis*.

Position and locality: Upper Helderberg, Falls of the Ohio.

RHOMBOPORA DICHOTOMA Ulrich.

Pl. LXX, Figs. 13-13b.

Zoarium dendroid, spread in the same plane, arising from an expanded base. Branches strong, about 3 mm. in diameter, dividing dichotomously at intervals of 10 to 15 mm.; angle of bifurcation about 85°. Surface with inconspicuous elevations, which sometimes continue around the branch as low annulations. Zoœcia apertures arranged in regular intersecting spiral series, crossing each other at an angle of about 90°. These lines are somewhat interrupted by the surface elevations, upon which the apertures are appreciably larger than elsewhere. Toward the upper ends of the branches the interspaces are obtusely ridge-shaped, the apertures circular, 0.12 mm. in diameter, and situated at the bottom of a rhomboidal sloping area. The summit of the ridge with a closely arranged series of small nodes, of which the one at the angles of the rhomb is usually the largest. Toward the base the diameter of the apertures is gradually decreased to 0.08 or 0.09 mm., by the thickening of the interspaces. The latter has also become rounded, and the nodes a little larger and less regularly arranged. Measuring diagonally thirteen apertures occur in 4 mm.; longitudinally seven or eight in the same space.

This species is related to *R. lepidodendroides* Meek, from the Upper Coal Measures, but differs in its mode of growth, less prominent large tubercle, and the thickening of the interspaces with age. *R. varians* has both smaller zoœcia and nodes.

Position and locality: The type specimen is from the Burlington limestone, at Burlington, Iowa. I have collected seven fragments of what seems the same species from the Keokuk limestone at Warsaw, Ill. A comparison of their internal characters is necessary before their absolute identity can be admitted.

RHOMBOPORA GRACILIS Ulrich.

Pl. LXX, figs. 11-11*b*.

Zoarium a long filiform stem, about 1.3 mm. in diameter, branching dishotomously at intervals varying from 8 to 30 mm. Angle of bifurcation varying between 60° and 90°. The specimen figured has a total length of 10.5 cm. Zoœcia apertures small, oval, 0.1 mm. long, usually arranged in longitudinal and diagonally intersecting series, with six or seven in the first, and nine in the second, in 2 mm. Interspaces ridge-shaped, the summit rather sharp, and enclosing an hexagonal or sub-rhomboidal area which slopes down into the aperture. A small node may be developed at the angles of junction.

This very neat species differs from *R. dichotoma* in its more slender branches, and in wanting the row of nodes on the interspaces. *R. exigua* is more slender and has granulose interspaces.

Position and locality: Burlington limestone, Burlington, Iowa.

RHOMBOPORA EXIGUA Ulrich.

Pl. LXX, figs. 10, 10a.

Zoarium consisting of very slender cylindrical stems, from 0.6 to 0.8 mm. in diameter. None of the fragments seen are branched. Zoœcia apertures arranged in quite regular, diagonally intersecting, and rapidly ascending spiral series. Also in less regular transverse and longitudinal rows. Apertures oval, about 0.11 mm. long, situated at the bottom of the sloping area, with four in 1 mm. diagonally, and three in 5 mm. transversely. Sloping area narrow, lozenge-shaped or sub-hexagonal, not sharply margined, the summit of the interspace being narrowly rounded and occupied by a row of closely set small granules. Often two rows of granules prevail for a short distance.

The granulose interspaces and more slender stems separate this species from *R. gracilis* with which it is associated. *R. attenuata*, from the Keokuk group, has larger and more regularly arranged zoœcia apertures, and sharply margined areas.

Position and locality: Burlington group, Burlington, Iowa.

Rhombopora angustata Ulrich.

Pl. LXX, figs. 6, 6*a*.

Zoarium an exceedingly slender cylindrical stem, 0.4 to 0.5 mm. in diameter; not observed to branch, but probably doing so at long intervals. Zoœcia apertures arranged in rather irregular diagonally intersecting series. Sloping area large, elongate elliptical or lozenge-shaped, averaging 0.5 mm. long by 0.2 mm. wide. Summit of interspaces sharp, crowded with a closely arranged row of small nodes, which form flexuous longitudinal lines. Apertures 0.17 mm. long and one-half as wide, about five in 3 mm. longitudinally. It requires between five and six zoœcia to form one oblique volution about the stem.

The small size of the stems, the comparatively large zoœcia, and the elongate sloping area about their apertures, constitute the distinguishing features of this species.

Position and locality: Keokuk group. Rather rare at King's Mountain, Ky.

Rhombopora incrassata Ulrich.

Pl. LXX, figs. 12-12*d*.

Zoarium a rather robust straight stem, from 1.2 to 1.8 mm. in diameter, occasionally sending off branches of the same size at about a right angle. Apertures arranged transversely, longitudinally, and in diagonally intersecting series which ascend the stem spirally, making an angle of about 40° with the axis of the stem. Interspaces very thick, ridge-shaped, bearing upon the summit a single or sometimes double series of closely set nodes (? acanthopores) enclosing the sloping area at the bottom of which the aperture is situated. Area deep, oval or subrhombic in outline. Apertures oval, 0.17 mm. long by 0.09 mm. wide, with five in 2 mm. diagonally. About thirteen of the transverse rows occur in 5 mm.

Thin sections show that the zoœcial tubes are arranged in a wedge-shaped manner about the center, and that the nodes are really the surface projections of thick-walled tubes.

This species resembles *R. dichotoma*, of the Burlington limestone, but is distinguished superficially by its larger zoœcia, smaller apertures, and deeper area.

Position and locality: Keokuk group. Not uncommon at King's Mountain, and Button Mould Knob, near Louisville, Ky.

RHOMBOPORA VARIANS Ulrich.

Pl. LXXI, fig. 1-1b.

Zoarium consisting of robust stems, 2 to 4 mm. in thickness, which arise from an irregularly porous basal expansion, and usually branch dichotomously at variable intervals. Angles of bifurcation more or less wide. Zoœcia apertures arranged in diagonally intersecting and longitudinal series, with seven in 2 mm. measuring diagonally, and fifteen or sixteen in 5 mm. vertically. Interspaces decreasing somewhat in thickness from below upward, and varying considerably in character at the two extremes, the extent of the variability depending upon the age of the specimen. On the distal or young portions of the zoarium, the interspaces are ridge-shaped, with the summit sharply defined and carrying a single series of minute granules. The area is elongate hexagonal in outline, 0.24 by 0.33 mm., with the ends truncated, and slopes with moderate rapidity down to the oval aperture, which has a length of 0.12 or 0.13 mm. Toward the base the interspaces gradually loose their angularity, the granules increase in number from one to two, and then three irregular rows, while the apertures become more nearly circular, and, near the expanded base of the zoarium, may even be surrounded by a faint peristome, the interspaces having ere this become perfectly flat.

Vertical sections show that the primitive or immature region of the zoœcial tubes may be intersected by an occasional thin diaphragm, that the superior hemiseptum is strong, and that delicate diaphragms are often preserved in the vestibnlar region of old examples. In tangential sections the appearance at different stages in the development of the zoarium, as above described, are easily traced out.

This species is distinguished from *R. dichotoma* and its Keokuk representative, by its smaller zoœcia and the absence of the strong acanthopores between the ends of the area. This feature is particularly prominent in the Keokuk examples which I have provisionally arranged with the Burlington species.

Position and locality: Keokuk group; near Plymouth; near Whitehall, in Greene Co.; Warsaw and Nauvoo; all localities in Illinois.

RHOMBOPORA TRANSVERSALIS Ulrich.

Pl. LXXI, fig. 4—4b.

Zoarium a comparatively robust stem, 2.5 to 4 mm. in diameter, branching dichotomously, at intervals of 12 mm. or more. Angle of bifurcation generally about 60°. Young branches commonly found flattened from pressure. The surface of the branches is marked by transverse annulations, about 1.7 mm. apart. They are formed by the periodic channel-like prolongation of the anterior end of the depressed areas of transverse series of zoœcia apertures. In old examples, in which the interspaces are thicker and more rounded than in young specimens, the annulations are the most distinct, appearing like narrow and slightly depressed solid bands. In young examples they are much obscured by the ridge-like prominence of the interspaces, but as their position is always indicated by a slight elevation of the surface, the feature constitutes a reliable distinctive character. Interspaces thick and rounded in the mature specimens, less so, even rather thin and ridge-shaped in those that are younger; and carrying from one to three series of small closely crowded granules. Depressed areas, (*i. e.*, the space bounded by the summits of the interspaces,) more or less lozenge-shaped, this shape prevailing especially in young examples. At the bottom of the areas are situated the ovate apertures, whose long diameter is about 0.12

mm. The arrangement of the apertures is not very regular. The longitudinal series are as a rule more noticeable than the diagonal rows. The latter intersect each other at an angle of 90° or more. Measuring longitudinally, twelve to fourteen apertures occur in 5 mm.; diagonally 6.5 to 7.5 in 2 mm.

The transverse marking of the branches, and the less regular arrangement of the zoœcia apertures separate this species from *R. varians*. None of the other are very closely related.

Position and locality: Keokuk group, Plymouth, Nauvoo and Warsaw. Ill.

RHOMBOPORA ATTENUAT\ Ulrich.

Pl. LXX, fig. 7.

Zoarium a slender stem, from 0.7 to 1 mm. in diameter; not observed to branch. Zoœcia apertures arranged very regularly in longitudinal and diagonal series, which intersect each other at an angle of about 45°. Interspaces rather thin, acutely ridge-shaped, bearing upon the summit a single series of very small and closely set nodes. The node at the angle is commonly larger than the others. Areas rather narrow, regularly long-hexagonal, truncated at the ends, sloping rapidly down into the oval aperture, whose long diameter is about 0.15 mm., the shorter 0.10 mm. Longitudinally, there are sixteen apertures in 5 mm.; diagonally five in 1 mm.

This species is closely allied to *R. wortheni* from the Lower Carboniferous (?Keokuk) deposits of Kentucky. The cells of that species are a little larger and scarcely so regular in their arrangement, and the stems stronger, being from 1.2 to 1.8 mm. in diameter. The *R. exigua* of the Burlington limestone, is even more slender, has smaller apertures, rounded interspaces, larger granules, and the ends of the areas pointed instead of truncate. The last fact causes the diagonal rows of apertures to ascend more rapidly in their spiral course around the stems.

Position and locality: Not uncommon in the upper layers of the Keokuk group at Warsaw, Ill.

RHOMBOPORA? ASPERULA Ulrich.

Pl. LXX, figs. 9—9e.

Zoarium ramose, growing from an expanded base, attached to foreign bodies. Stems from 1.0 to 1.6 mm. in diameter, branching dichotomously at variable intervals. When in a good state of preservation the surface is very rough or hirsute, the blunt spines or acanthopores being very prominent, and so abundant that the zoœcia apertures are obscured by them. Apertures usually suboval, but rather variable in size, shape, and arrangement. Measuring in an obliquely transverse direction, about six occur in 1 mm. Interspaces rounded, varying in thickness from one-fourth to three-fourths or more of the diameter of the apertures, depending largely upon the maturity of the specimen.

The irregular arrangement of the zoœcia apertures, and the prominence of the spines, distinguish this species from all others of the genus known to me. The first peculiarity is so at variance with the ordinary species of the genus that I am inclined to believe that better sections than I have yet been able to prepare will show the species to belong to some other genus, probably *Batostomella*.

Position and locality: Keokuk group; Keokuk, Iowa, Nauvoo and Warsaw, Ill.

RHOMBOPORA? SPIRALIS Ulrich.

Pl. LXXI, Fig. 5-5d.

Zoarium a rather robust stem, 1.5 to 2 mm. in diameter, not observed to branch. Zoœcia apertures arranged in diagonal spiral series which intersect at an angle of between 70° and 80°. Measuring along the series there are five in 2 mm. The apertures are subcircular, 0.21 mm. in diameter, and separated by rounded interspaces, bearing a single or double series of contiguous hollow nodes, which are represented by a series of minute pores when the surface of the zoarium is abraded. These pores are quite distinct in thin sections, though not of uniform size, those in the longitudinal interspaces being the largest. Transverse sections are interesting because they show that the zoœcia are arranged in a spiral manner about the axis of the branch. This is a very unusual feature among Palæozoic Bryozoa.

The position of this species is doubtful, and more material is required before its relations can be determined satisfactorily. It may turn out to be a *Streblotrypa*.

Position and locality: Keokuk group, King's Mountain, Ky.

RHOMBOPORA SIMULATRIX Ulrich.

Pl. LXXI, figs. 2-2e.

Zoarium ramose, branches slender, varying from 1.0 to 2.1 mm. in diameter, dividing dichotomously at intervals of from 10 to 15 mm. Zoœcia apertures oval, averaging 0.12 mm. in length, arranged in only moderately regular, diagonally intersecting and longitudinal series, with sometimes one and then the other arrangement the most noticeable. Measuring longitudinally, five or six apertures occur in 2 mm.; diagonally, nine in younger examples and eight in the older ones in 2 mm. Interspaces becoming flatter and increasing in thickness with age, usually wider than the zoœcia apertures; in the young examples, narrowly rounded, and crowned with a single series of small, close set granules, with one of larger size between the ends of the oval depressed areas. On the larger specimens the interspaces may be nearly flat and occupied by two or three rows of granules.

The internal characters of a mature example are very well shown in figs. 2d and 2e.

This species resembles several others but is really not very closely related to any. Small specimens present external resemblance to *R. minor*, of the Chester group, but the internal structure of the two is quite different, and points rather to a relationship with *R. wortheni* and *R. decipiens*.

Position and locality: St. Louis group, at Columbia and other localities in Monroe county, Ill.

RHOMBOPORA DECIPIENS Ulrich.

Pl. LXXI, fig. 3-3d.

Zoarium ramose, the branches rather robust, 1.5 to 3 mm. in diameter, divided dichotomously at variable intervals. Zoœcia apertures oval, a little oblique, averaging 0.15 mm. in length by 0.10 mm. in width, arranged in more or less interrupted lines, which may be vertical, diagonal, or transverse.

In young examples the arrangement appears to be rather more regular than in the larger ones. Measuring longitudinally, or transversely, five or six in 1 mm. Interspaces rather thin, rounded, not appreciably different in young and old examples, carrying small tubercles about equal in number to the zoœcia apertures.

Of internal characters those furnished by vertical sections are the most interesting. (See Pl. LXXI, fig. 3c.)

Large examples of this species especially remind one very much of such TREPOSTOMATA as *Batostomella*, but thin sections prove beyond question that it is a true species of *Rhombopora* with close relations to *R. wortheni* and *R. simulatrix*. From the former it is distinguished by the ramose habit of growth, and much less regular arrangement of the zoœcia apertures. The latter differs in having more slender branches, thicker and granulose interspaces, and more regularly arranged zoœcia apertures.

Position and locality: St. Louis group. Monroe county, Ill.

RHOMBOPORA TABULATA Ulrich.

Pl. LXX, fig. 2-2c.

Zoarium a cylindrical stem from 1 to 1.5 mm. in diameter, branching dichotomously at intervals of 10 mm. more or less. Zoœcia apertures ovate, overaging 0.18 mm. in length, from one-half to two-thirds as wide, arranged in irregular series, with the transverse and diagonal lines less frequently dominant than the longitudinal. On an average five apertures occur in 2 mm. transversely, and from twelve to fourteen in 5 mm. longitudinally. Measuring diagonally, seven is the usual number in 2 mm. Interspaces carinate, as wide or wider than the zoœcia apertures, carrying at most of the angles of junction a moderately large tubercle. Sloping areas varying considerably in form, being sometimes hexagonal, and at other times pentagonal, lozenge-shaped, or irregularly quadrate.

Thin sections, aside from showing that the species is rather closely related to *R. persimilis*, are interesting because of the comparative abundance of true diaphragms in the axial or primitive portion of the zoœcia tubes. These and other characters of a vertical section are well shown in fig. 2c.

R. persimilis has the zoœcia apertures arranged in regular diagonally intersecting series (about as in fig. 12b, Pl. LXX), the summit of the interspaces granulose when perfect, and the tubes in the axial region straighter and without diaphragms. In the Burlington limestone species *R. gracilis*, the zoœcia are smaller and differently arranged.

Position and locality: Chester group. Rather abundant at Kaskaskia, Ill. Less common at Chester, Illinois, and Sloan's Valley, Ky.

RHOMPOPORA PERSIMILIS Ulrich.

Pl. LXX, fig. 3.

Rhombopora persimilis Ulrich, 1884. "Am. Pal. Bry." Jour. Cin. Soc. Nat. Hist. Vol. VII, p. 30.

The figure above cited represents an unusually large example of this species, in a slightly abraded condition. The arrangement of the zoœcia is as in the typical specimens, only the apertures are a trifle wider, since, measuring transversely, there are only five where they show six. This, I believe, is accounted for by the increased circumference of the larger specimen. Measuring diagonally both show eight in 2 mm., and longitudinally nine and ten in 5 mm.

Position and locality: Chester group. The specimen here figured is from Chester, Ill., where more typical examples have also been found in moderate abundance. The species also occurs at other localities in Illinois, and at Sloan's Valley (Tateville), Kentucky.

RHOMBOPORA MINOR Ulrich.

Pl. LXX, fig. 4-4a.

Zoarium irregularly ramose, branches not rigid, from 0.5 to 0.9 mm. in diameter. Zoœcia apertures suboval, averaging 0.12 mm. in length, situated at the bottom of the deep and illy defined areas; arranged, generally, in rapidly ascending but not very regular diagonal series, with about four in 1 mm. Interspaces narrowly rounded, never carinate, carrying, beside a single row of small, closely set nodes, some that are of larger size, and usually situated between the ends of the suboval areas.

Vertical sections are similar to those of *R. tabulata*, but the diaphragms seem comparatively more numerous. The zoœcial tubes seem also to be shorter. Externally *R. minor* differs from that species in its smaller zoœcia and row of closely set nodes on the interspaces. The zoarium is also much smaller. *R. persimilis* has ridge-shaped interspaces, much more regularly arranged zoœcia, and, so far as known, no diaphragms in the zoœcial tubes.

Position and locality: Chester group. Sloan's Valley, and Litchfield, Ky.

Rhombopora tenuirama Ulrich.

Pl. LXX, fig. 8-8b.

Zoarium very small, consisting of exceedingly slender stems, which may divide dichotomously or send off branches at right angles. Diameter of stems varying between 0.4 and 0.5 mm. Zoœcia apertures oval, about 0.11 mm. long, from one-half to two-thirds as wide, arranged in longitudinal and diagonally intersecting series, between somewhat flexuous, subangular, longitudinal ridges, which have a more or less irregular appearance because of the unequal distribution of the two sizes of spines carried by them. Sometimes the smaller spines are in contact, at other times widely separated. The areas are more or less confluent, with the sides rather wide and slightly convex. The spiral rows of apertures intersect at an angle of about 75°, and it requires nine or ten of the apertures to make one volution about the stem. Measuring longitudinally, eleven apertures occur in 4 mm.

The exceeding minuteness of the zoarium, the comparatively strong spines, and the longitudinal arrangement of the zoœcia between strong ridges. are the distinctive features of this species. *R. minor* is larger, and has the zoœcia differently arranged. *R. angustata*, of the Keokuk group, has much larger zoœcia, and does not branch at such short intervals.

Position and locality: Chester group. Kaskaskia, Illinois, and Sloan's Valley, Ky.

RHOMBOPORA NICKLESI Ulrich.

Pl. LXX, fig. 1—1c.

Zoarium consisting of small, dichotomously branching stems, averaging 0.6 mm. in diameter, but varying from 0.4 to 0.9 mm. Interspaces rather narrow, sloping rapidly down on each side into the oval apertures, which have an average length of about 0.17 mm. The summit of the interspaces is narrowly rounded or sub-angular, and mostly smooth, excepting at the angles of junction, where it rises into a more or less conspicuous node. On each side of the summit, and marking the top of the suboval or lozenge-shaped area, there is an exceedingly minute series of closely arranged granules, which are too small to be shown in the illustrations. Zoœcia apertures ranged in rather regular diagonal lines, intersecting at an angle of about 65°; with four in 1 mm. Sometimes the zoœcia apertures are narrower on one side of the stem than on the other.

The external appearance of this species is very much like that of *Rhabdomeson rhombiferum* Phillips, from the Carboniferous shales of Scotland, but numerous thin sections show that there is no axial tube, and that the minute characters agree in all respects with *Rhombopora*. *R. lepidodendroides* Meek, is larger, and has a single or double row of distinct granules on the summit of the interspaces between the large spines at the angles. *R. persimilis* of the Chester limestone has wider interspaces and differs internally.

The specific name is given in honor of Mr. J. M. Nickles, of Sparta, Illinois, to whom we are indebted for the discovery of this and many other new Bryozoa from the Lower Carboniferous and Coal Measure deposits of Illinois.

Position and locality: Lower Coal Measures, Sparta, Ill.

ACANTHOCLEMA Hall, 1887.

(Pal. N. Y. Vol. VI, p. XV.)

(For generic diagnosis see page 402).

I propose, provisionally, to adopt this genus, for species differing from typical *Rhombopora* in having the zoœcia apertures arranged between longitudinal ridges. Some of the species placed by Hall under his *Orthopora*, as also several of my species of *Rhombopora* should, perhaps, have been referred here.

ACANTHOCLEMA CONFLUENS Ulrich.

Pl. LXX, Fig. 5-5b.

Zoarium a slender stem, 1 mm. or a little more in diameter, bifurcating at intervals, frequently found flattened by pressure in the shales. Zoœcia apertures oval, 0.12 mm. long, two-thirds as wide, arranged very regularly in longitudinal, transverse, and diagonally ascending series, between sharply angular, and regularly flexuous, longitudinal ridges, which alternately recede and approach each other, without, however, at any time coming in contact. The sloping areas are confluent, *i. e.*, they communicate with each other by means of a narrow channel which is left between the ridges. Between this channel and the lower end of the aperture there is a distinct, though not large tubercle, that scarcely projects beyond the level of the ridge summits. Measuring longitudinally, between nine and ten apertures occur in 4 mm.; diagonally, about nine in 2 mm.; transversely, five in 1 mm.

None of the species known to me resemble this one sufficiently to require comparisons.

Position and locality: Keokuk group, Nauvoo, Ill.

BACTROPORA Hall, 1887.

(Pal. N. Y. Vol. VI, p. XV.)

(For generic diagnosis see page 402.)

Species of this genus are characterized by a free and unbranched zoarium, the basal extremity being pointed and the remainder a simple, slightly curved or straight, solid, cylindrical stem. In their minute features the zoœcia and zoarium differ in no essential respect from *Rhombopora*. The "solid" character of the stems distinguishes them from *Cœloconus*.

Bactropora simplex Ulrich.

Pl. LXX, fig. 14-14b and Pl. LXXI, fig. 6-6a.

Zoarium free, consisting of a simple, unbranched, straight or slightly curved stem. An average specimen is 1.5 mm. in diameter and 18 mm. long. The largest seen is nearly 30 mm. long and 1.8 mm. in diameter. The upper extremity is rounded, the lower is striated and tapers rapidly to a point. Surface with small, transversely elongated monticules which often appear as annulations but really never continue more than half way around the stem, and only rarely more than one-third the way. These semi-annulations or monticules are developed in two alternating series on opposite sides of the cylindrical stem. Those of each series are placed directly above one another, the distance from summit to summit being about 1.5 mm. Zoœcia apertures oval or sub-circular, about 0.12 mm. in diameter, arranged in spiral diagonal lines which intersect each other at an angle of about 67°. Measuring diagonally, nine apertures occur in 2 mm.; transversely, five in 1 mm. Interspaces seldom equal in width to the diameter of the apertures, generally considerably less, thickest and less acutely rounded toward the base, the summit occupied by a single or double row of small closely set acanthopores, which have a peculiar rayed appearance in tangential sections.

Zoœcial tubes thin-walled in the axial region, proceeding from the center of the stems toward the surface at an angle of about 45°. At the beginning of the peripheral region their walls are much, though not excessively, thickened. In this zone the peculiar stellate acanthopores make their appearance. In vertical sections they appear as vertical series of minute dots.

The free and unbranched character of the zoarium of this species is so marked a feature that complete specimens may be distinguished at once from associated bryozoa. The transversely elongated monticules are also very distinctive. The Devonian types of the genus are without surface elevations.

Position and locality: Keokuk group. Abundant at Keokuk, Iowa; Nauvoo and Warsaw, Ill.

Cœloconus Ulrich.

(For generic diagnosis see page 402.)

This genus, though closely related to *Rhombopora* and *Rhabdomeson*, is amply distinguished by its zoarial and zoœcial peculiarities, The free character of the zoarium, its hollow conical form, and the comparatively short zoœcia, are the chief features of the genus. So far only two species are known to have these characters. In *Bactropora* Hall, the zoarium is also free, but neither conical nor hollow, the entire axial region of the cylindrical stems being occupied by the tubular primitive portion of the zoœcia.

Cœloconus rhombicus Ulrich.

Pl. LXXII, fig. 4–4c.

Zoarium a hollow elongate-obconical body, 8 to 10 mm. long, and about 1.5 mm. wide across the open top; lined on the inner side with a thin epitheca. Thickness of the zoarial crust about 0.2 mm. Zoœcia apertures differently arranged on different portions of the surface. Near the pointed base they are narrow and ranged between raised longitudinal lines, which give this portion of the zoarium the appearance of being striated. Farther up they gradually become suboval, occupy the bottom of sharply defined rhombiform sloping areas, arranged in rather regular diagonally intersecting series. Toward the upper end the areas gradually change from rhombic to regularly elongate hexagonal, with the ends acute. At the same time an arrangement of the areas in transverse series becomes evident. The interspaces are rather thin and, in the usual state of preservation, (in which the summit alone projects above the infilling matrix) appear very delicate. At the angles of junction the summit is slightly elevated. Measuring longitudinally, about six zoœcia apertures occur in 2 mm.; diagonally, five in 1 mm.; transversely, five in 1 mm.

Thin sections show that the zoœcial walls are comparatively thin throughout, that the zoœcia are short, ranged in longitudinal series on the basal plate, and provided with both hemisepta, the inferior one but little developed.

The conical form of the zoarium distinguishes this form from all the Lower Carboniferous Bryozoa, known to me, excepting the next described.

I am indebted to Mr. J. M. Nickles for the only specimens seen of this species.

Position and locality: St. Louis group; Fountain Creek, Monroe county, Illinois.

Cœloconus granosus Ulrich.

Pl. LXXII, Fig. 3-3b.

Zoarium elongate cone-shaped, hollow, with a rather thick, transversely striated epithecal lining, apparently perforated by minute tubuli. Thickness of entire zoarial crust about 0.3 mm. Cone from 8 to 12 mm. long, and from 1.3 to 2 mm. wide across the open top. Base attenuate, usually deflected a little to one side. Zoœcia arranged as in *C. rhombicus*, but with the interspaces higher, granulose, and the summit more rounded; the area more abruptly impressed, deeper, and not so sharply outlined, appearing, in the lower two-thirds of the zoarium, to be rather of oval shape than rhombic. Apertures varying from oval to sub-circular, 0.1 mm. in diameter; measuring longitudinally, there are between six and seven in 2 mm.; diagonally between four and five in 1 mm.; transversely, five and often six in 1 mm.

Of internal characters, the most striking is the strength of the basal lamina and zoœcia walls when compared with *C. rhombicus*.

Position and locality: Chester group; near Anna, Union Co., Ill.

Streblotrypa Ulrich.

Acanthoclema Hall (pars). Pal. N. Y., vol. VI, 1887.

(For generic diagnosis see page 403.)

In its superficial characters the typical species of this genus greatly resembles species of D'Orbigny's *Cavea* (*C. costata, et regularis*), but whether this resemblance is due to real relationship, or is only incidental, remains to be seen. Compared with

Rhombopora, the principal difference is found in the more or less numerous pores which (normally) are situated back of the zoœcia apertures.

The Devonian species of the genus Hall has placed under his new genus *Acanthoclema*. They are, however, quite distinct from his *A. alternatum*, which is mentioned as the type, and which is closely related to *Rhombopora*.

STREBLOTRYPA MAJOR Ulrich.

Pl. LXXI, fig. 8-8d. and Pl. LXXII, fig. 1,1a.

Zoarium a comparatively robust, dichotomously or otherwise dividing stem. Often found flattened from pressure. The divisions of the branches occur at long intervals and are often unequal. Zoœcia apertures oval, 0.25 mm. long and about 0.15 mm. wide, surrounded by a narrow sloping area, only noticeable in perfect specimens; arranged in longitudinal series (interrupted at more or less frequent intervals) between subangular longitudinal ridges, that are not distinct from the aperture margins but form their lateral boundaries. The longitudinal interspaces between the succeeding zoœcia apertures exhibit the mouths of from one to three short ranges of mesopores. These pores vary considerably in size, and in number from three to twelve, but when the zoœcial arrangement is regular, their number is generally either four or six. Measuring longitudinally, about ten zoœcia apertures occur in 5 mm.

Of internal characters, the comparative shortness of the zoœcial tubes, the non-development of an inferior hemiseptum, and the rather irregular appearance of the tubes in the axial region, are the most noteworthy.

The large zoœcia and rather robust zoarium easily distinguish this species from all others of the genus so far known.

Position and locality: Keokuk group; King's Mountain, Ky.; Keokuk, Iowa; Nauvoo and other localities in Illinois. The specimens from Illinois are larger than those from Kentucky.

STREBLOTRYPA RADIALIS Ulrich.

Pl. LXXII, fig. 2-2d.

Zoarium consisting of slender, dichotomously dividing stems about 1 mm. in diameter, the whole forming a bushy mass growing from a central point out in all directions. Zoœcia apertures small, suboval, slightly truncated posteriorly, about 0.1 mm, long, two-thirds as wide, occupying the anterior half of the bottom of a sloping area. Area hexagonal in outline, truncated at the ends, about 0.28 mm. long, by 0.14 mm. wide, sloping gradually down into the aperture, which, as has been said, occupies the anterior half of the bottom. The posterior slope is more gentle than the anterior, and presents the mouths of from two to four very minute pores, which, unless the specimens are exceptionally preserved, are liable to be overlooked. The areas are ranged in very regular longitudinal and diagonally intersecting series, with eleven or twelve in 3 mm. longitudinally, and six in 1 mm. diagonally. The summit of the zigzag ridges formed by them is rather sharply defined and carries a crowded series of very minute granules.

The internal characters are very well shown by the illustrations. The chief distinctive feature shown by thin sections is the radial arrangement observed in transverse sections.

This species presents much superficial resemblance to *Rhombopora attenuata*, but a close comparison shows that they differ in important particulars. Of these the presence of small pores back of the zoœcia apertures in the present species, is the principal one. The apertures are also smaller and not situated in the middle of the area. *S. subspinosa*, of the Chester limestone, differs slightly in its measurements, has the areas less sharply defined, and the ridges somewhat tuberculated.

Position and locality: Keokuk group, near Nauvoo, Ill., and Bentonsport, Iowa.

STREBLOTRYPA NICKLESI Ulrich.

Pl. LXXI, figs. 9-9c.

Zoarium consisting of slender, sub-cylindrical, bifurcating stems, about 0.5 mm. in diameter. Zoœcial tubes very long, small, almost vertical in the middle of the axial region, approaching the surface slowly, and increasing in size at the same time. Between 0.2 and 0.3 mm. from the aperture a short inferior hemiseptum is developed. Zoœcia apertures ovate, slightly truncated posteriorly, 0.08 mm. long by 0.06 mm. wide, surrounded by a thin peristome highest at the anterior border. They are arranged in alternating longitudinal rows between thin ridges which unite with the peristomes and are about 0.1 mm. apart. The interspaces between the succeeding apertures is depressed and occupied by the mouths of from nine to fifteen small pores arranged in two or three rows. Measuring longitudinally six zoœcia apertures occur in 2 mm.; diagonally five in 1 mm. It requires about twelve rows to encircle the stem.

The small zoœcia apertures, their regular arrangement, and the large number of the (?) mesopores, are the distinguishing features of this species.

The specific name is given in honor of Mr. J. M. Nickles, of Sparta, Ill., to whom belongs the credit of first finding the species in abundance.

Position and locality: Chester group. Common at Kaskaskia and other localities in Ill., and at Sloan's Valley, Ky. According to Mr. Vine (Proc. Yorksh. Geol. Soc., vol. VIII, p. 107, 1885,) also in the Carboniferous shales of England.

STREBLOTRYPA SUBSPINOSA Ulrich.

Pl. LXXI, figs. 7-7a.

Zoarium consisting of long, slender, cylindrical stems, 0.7 or 0.8 mm. in diameter, branching dichotomously at varying intervals. Zoœcia apertures arranged alternately in longitudinal series, nine or ten in 3 mm.; diagonally five in 1 mm. Between the series are nearly straight longitudinal ridges carrying a variable number of small nodes. Between the ends of the depressed apertures, which occupy the bottom of distinct oval sloping areas, there are from two to four small mesopores. These sometimes occupy the transverse ridges, at other times the posterior slope of the area.

This species is closely allied to the *S. radialis*, of the Keokuk group, but differs in having the longitudinal ridges straighter and nodose, the area oval instead of hexagonal, the mesopores less regularly situated and often placed on the transverse ridges instead of within the area.

Position and locality: Chester group. Not uncommon at Chester, Ill., and Sloan's Valley, Ky.

STEBLOTRYPA DISTINCTA Ulrich.

Pl. LXXI, fig. 10-10*b*.

Zoarium consisting of slender dichotomizing stems, from 0.5 to 0.7 mm. in diameter. A small slab is almost made up of fragments, from which we may judge the zoarium formed bushy masses. Zoœcia apertures generally arranged in longitudinal series, but there are no ridges between the rows. Occasionally a transverse arrangement will predominate, and, more rarely, diagonally intersecting rows are formed. On the whole the arrangement is inclined to be irregular. On an average eight occur in 2 mm. Apertures oval, 0.10 or 0.11 mm. long, by 0.07 or 0.08 mm. wide, with the margin somewhat elevated. Interspaces slightly depressed, varying considerably in width, occupied by more or less numerous, small but unequal mesopores. The interspaces between the sides of the peristomes are usually linear.

The rather irregular arrangement of the zoœcia and mesopores, and the absence of longitudinal ridges, give this species a very distinctive and characteristic appearance.

Position and locality: Chester group. Chester, Ill.

WORTHENOPORA Ulrich.

(For generic diagnosis see page 403.)

WORTHENOPORA SPINOSA Ulrich.

Pl. LXVIII, Fig. 1-1g.

Zoarium a bilaminar elongate frond, 3 or 4 mm. wide, 0.5 to 0.8 mm. in thickness, branching dichotomously or otherwise at long intervals. Acutely elliptical in cross section. Margins sub-parallel, armed with a series of slender spines from 0.3 to 0.5 mm. long. pointing obliquely upward and outward. There are on each side about sixteen in 3 mm. Zoœcia enclosed by an elevated sub-angular ridge, common to adjoining zoœcia. The space enclosed is elongate, somewhat rhombic in shape, drawn out long wedge-shaped posteriorly, and more rounded anteriorly; the whole usually 0.6 mm. long and 0.12 mm wide. Aperture semi-elliptical, truncated posteriorly, 0.18 mm. long, and 0.1 mm. wide, occupying the anterior third of the space enclosed by the ridges, which form its margin except at the posterior side, where a thinner and less elevated line separates the aperture from the remainder of the enclosure. The latter forms an irregular sub-triangular depressed space, with the bottom smooth and slightly concave. When perfect five small tubercles, one on the posterior and two on each of the lateral margins, project into the aperture. Apertures arranged in regular, acutely intersecting, diagonal series, nine in 3 mm., and in less regular transverse rows, between eight and nine in 2 mm. The marginal rows of zoœcia are usually a little larger than the central ones.

Position and locality: Keokuk group. Warsaw and Nauvoo, Ill.; Keokuk and Bentonsport, Iowa; Warsaw beds, at Warsaw, Ill.

WORTHENOPORA SPATULATA Prout.

Pl. LXVIII, figs. 2-2a.

Flustra spatulata Prout, 1859. Trans. St. Louis Acad. Sci. vol 1, p. 446, Pl. 17, fig. 2-2c.

This species differs from *W. spinosa* mainly in the form of the zoarium which is always more explanate, being usually of flabellate form. The margins are sharp and striate, and without spines. On one fragment many of the triangular suboral spaces are divided in half by a thin transverse ridge.

Position and locality: Warsaw beds, Warsaw, Ill., and Barrett's Station, St. Louis county, Mo.

CYCLOPORA Prout, 1860.

(Trans. St. Louis Acad. Sci. vol.1. p. 574.)

(For generic diagnosis see page 403.)

The utmost confusion has hitherto prevailed among palæontologists who have sought to determine the true characters of this genus. Such a condition of affairs appears natural enough, when we consider that according to Prout's description the principal feature of the genus is the concentrically and radially striated epithecal membrane ("sole"). The zoœcia are said by him to be sub-tubular, sub-prismatic, and separated by a porous interstitial net-work. The last character in conjunction with the preceding, suggests *Fistulipora*, but, when we examine his species, none of them show anything like the interstitial net-work of that genus. On the contrary, none of his original species, excepting *C. fungia*, which, being the first described, I regard as the type, have any interstitial cells whatever. *C. fungia* too, when normally developed, has only a depressed space back of the zoœcia aperture, which as growth proceeds is gradually drawn out into a tabulated mesopore. Four species are described by Prout, and these in themselves already show how extremely misleading an index to generic affinity is the common possession of a striated epitheca. Thus *C. discoidea* differs so much from *C. fungia* in its zoœcial features that I propose the new genus *Proutella* for it; *C. polymorpha* is a true *Stenopora*, and probably identical with his *Flustra tuberculata;* and *C. jamesi* is the same as *Ptilodictya pavonia* D'Orb.

The genus as now defined is based upon specimens that were identified by Dr. Prout himself with his *C. fungia*. It is still somewhat unsatisfactory, and much more work is necessary before the true position of the genus can be established.

CYCLOPORA FUNGIA Prout.

Pl. LXVIII, figs. 3-3g.

Cyclopora fungia Prout, 1860. Trans. St. Louis Acad. Sci. vol. 1, p. 577.

Cyclopora fungia Prout, 1866. Geol. Surv. Ill. vol. II, p. 419, Pl. 22, figs. 9-9b.

Zoarium an irregularly undulating sub-circular expansion, 1 mm. or less in thickness, and from 2 to 7 cms. wide. Under surface with an epithecal membrane, marked with irregular concentric wave-like wrinkles and faint radiating lines, the latter being the base of the zoœcia walls showing through; at the center there is a slightly raised or depressed cicatrix of attachment, about 5 mm. in diameter. Upper surface occasionally even, generally with more or less elevated monticules, composed of cells wider apart and rather larger than the average. Zoœcia for a short distance prostrate and thin-walled, then making a rather sharp curve, proceed direct to the surface; the walls have now become thicker and a number of mesopores developed, which may be intersected, according to age, by from one to four or more centrally perforated thick diaphragms. The zoœcial walls exhibit a large number of delicate transverse lines, which may represent minute connecting foramina. Some of the zoœcia also show several tooth-like processes projecting a short distance into the vestibular cavity. These denticles seem to have been developed at successive levels, perhaps in all the zoœcia. Apertures sub-circular, the posterior side usually somewhat straightened, averaging 0.15 mm. in diameter, surrounded by a thin and but little elevated peristome, that, sometimes at any rate, carries a number of very small granules. Between the monticules they are arranged in quincunx, thus forming transverse, longitudinal and diagonally intersecting rows, whose regularity is more or less disturbed around the monticules. The triangular or oblong quadrate space left between the apertures is occupied by one or two mesopores, either open or closed by a membrane.

Three specimens give the following measurements:

No. 1. Transversely, 11 apertures in 3 mm.
Eleven of the transverse rows in 3 mm.
Diagonally, 10 apertures in 3 mm.
Total number of apertures in 3 mm. square, 121.

In this specimen the interspaces between the apertures are triangular as in fig. 3d. It is from the Keokuk limestone, at Keokuk, Iowa.

No. 2. Transversely, 9 apertures in 3 mm.
Fourteen of the transverse rows in 3 mm.
Diagonally, 12 apertures in 3 mm.
Total in 3 mm. square, 126.

In this specimen the interspaces are long and narrow. It is from the base of the Warsaw beds, at Warsaw, Ill.

No. 3. Transversely, 7.5 apertures in 3 mm.
Sixteen of the transverse rows in 3 mm.
Diagonally, 12 apertures in 3 mm.
Total number in 3 mm. square, 120.

In this specimen the interspaces are wider and shorter than usual. Its surface is represented by figs. 3–3b. Keokuk group, Nauvoo, Ill.

Position and locality: A common species in the Keokuk and Warsaw beds at many localities in Illinois and Iowa.

CYCLOPORA EXPATIATA Ulrich.

Pl. LXVIII, fig. 4-4d.

Zoarium a very large unilaminar expansion, from 0.5 to 1 mm. thick; one specimen before me (incomplete) has a breadth of 15 cms. and a width of 8 cms.; occasionally incrusting, usually free, with the under surface protected by an epithecal membrane more or less rugosely wrinkled in an irregularly concentric manner. The wrinkles are crossed by faint radiating lines. Surface with scarcely elevated monticules, composed of small aggregations of mesopores and a few zoœcia of larger size than the average. Zoœcia apertures subcircular, 0.2 mm. in diameter, not very regularly arranged, ten or eleven in 3 mm., often completely isolated by the large, irregularly shaped mesopores, but usually in contact with each other at one or more points. A thin peristome, carrying from four to eight nodes (? acanthopores) surrounds the apertures. In thin sections the walls are thin and exhibit considerable variability of structure, probably indicative of developmental stages, the sequence of which has not been determined. Sometimes the transversely lined structure shown in fig. 3e, Pl. LXVIII, is quite distinct, but usually the appearance is more like what is shown by figs. 4–4c of the same plate. Several diaphragms intersect the zoœcial tubes in vertical sections.

This species differs from *C. fungia*, in the larger size of the expansion, the well developed acanthopores, and less regular arrangement of the zoœcia. Tangential sections of the two look quite different.

Position and locality: Keokuk group. Warsaw and Nauvoo, Ill.

PROUTELLA Ulrich.

(For generic diagnosis see page 403.)

This genus approaches very near to some of the CHILOSTOMATA, but agrees with the CRYPTOSTOMATA in having the zoœcia layers follow each other in direct sequence so as to form tubes. *Proutella* furnishes a powerful argument in favor of the view published in my "American Palæozoic Bryozoa" as to the functions or purpose of diaphragms.

PROUTELLA DISCOIDEA Prout.

Pl. LXIX, fig. 4-4d.

Cyclopora discoidea Prout, 1860. Trans. St. Louis Acad. Sci., Vol. 1, p. 578.

Cyclopora discoidea Prout, 1866. Geol. Surv. Ill., Vol. II, p. 420, Pl. XXII, fig. 10-10a, and Pl. XXI, fig. 2-2a.

Zoarium a thin sub-circular expansion, several cm. in diameter, and less than 1 mm. in thickness. Lower or epithecal surface convex, with a short peduncle at the center, and around it more or less strong concentric undulations or sharp wrinkles; crossing these there are fine radiating striæ, which correspond with the arrangement of the zoœcia, as is shown by the application of moisture, when the oblong procumbent portion of the zoœcia is brought to view. Upper or celluliferous surface more or less concave, with the rhombic or hexagonal zoœcia arranged in very regular curved intersecting lines, about nine in three mm. Apertures a little oblique, rounded or sub-rhomboidal, about 0.28 mm. in diameter, of nearly uniform size throughout; occasionally preserving a delicate membrane, which closes somewhat more than one-half of the opening, the orifice left being sub-triangular in form and situated at the anterior or depressed side of the aperture. Interspaces ridge-like, with the angles a little elevated. As shown by vertical sections, the short zoœcial tubes run from the basal membrane to the upper surface with a gradual curve, without, however, becoming direct at the apertures. According to the thickness of the expansion, each tube exhibits from one to four incomplete diaphragms, which spring at a right angle from the posterior wall and extend to a point a little further than midway to the opposite wall. The intervals between them about equal the diameter of a zoœcium. These incomplete diaphragms may also be detected in tangential sections.

Prout's description and figures of his *Cyclopora discoidea*, leave so much unsaid that I found it quite impossible to identify the species with certainty. As, however, several of the specimens used in drawing up the above diagnosis of the species were so named by Dr. Prout himself, I feel reasonably confident that they are the same as the original examples. Three outwardly very similar yet very distinct species, the *Cyclopora fungia* Prout, *Cycloporella spinifera* Ulr., and the present species, are associated in the Keokuk limestone at Warsaw and other localities in the State. The difficulty of separating them is greatly aggravated by the fact, that in perhaps nine cases out of ten, the specimens show only the under side. Here they look decidedly alike and it was only after considerable practice that I could separate them successfully. Thin sections will, of course, immediately distinguish the species, while there is also very little difficulty in separating specimens showing the celluliferous side.

Position and locality: Keokuk group. Warsaw, Hamilton, and Nauvoo, Illinois, and Keokuk, Iowa.

Cycloporella Ulrich.

(For generic diagnosis see page 404.)

This genus is founded upon *C. spinifera*. Provisionally I place another species here, though fully aware that it is widely different from the type.

Cycloporella spinifera Ulrich.

Pl. LXIX, fig. 1-1c.

Zoarium discoidal, thickness 1 mm. or less. Under surface nearly flat, with a small central elevated scar of attachment; epitheca showing faint concentric wrinkles and radiating striæ. Upper surface strongly spinulose, sometimes with smooth spots, at irregular intervals, consisting of clusters of mesopores. Zoœcia apertures obscured by the projecting acanthopores, subangular, 0.15 mm. in diameter, with those in the immediate vicinity of the "maculæ" of much larger size, the largest being about 0.28 mm. in diameter. The arrangement is in irregular series with nine or ten of those in the intermacular spaces in 2 mm. Mesopores numerous, of unequal sizes, irregularly distributed, never isolating the zoœcia, and much obscured by the acanthopores. The latter are large and slightly exceed the zoœcia in number.

From thin sections we learn that the zoœcia are at first prostrate and thin-walled, then bending abruptly proceed direct to the surface. The walls become thickened and apparently amalgamated, the mesopores and acanthopores are developed, and, at intervals of about 0.1 mm., several superior hemisepta will be seen, in vertical sections, to project from the posterior wall into the zoœcial cavity. The cavity of the acanthopores is comparatively large and crossed by closely set, delicate diaphragms; their walls are composed of obliquely laminated tissue. The mesopores appear largely filled by a structureless deposit in which an occasional diaphragm may be detected.

When the under surface alone is visible the species might be confounded with *Proutella discoidea*. A little moisture applied to the epitheca will show that that species has larger cells, the radiating lines being farther apart. The under surface of *Cyclopora fungia* is strongly wrinkled; that of *Cycloporella? perversa* even more so.

Position and locality: Keokuk group, Warsaw, Ill.

CYCLOPORELLA ? PERVERSA Ulrich.

Pl. LXIX, figs. 3-3b.

Zoarium a free or parasitically attached, thin, irregular expansion, 8 to 10 cms. in diameter, and from 0.5 to 2.0 mm. in thickness, being often composed of two or three superimposed layers. When free the lower surface is strongly wrinkled, the zoarium appearing sometimes like a crumpled piece of cloth. Zoœcial tubes with a short prostrate region, bending soon to proceed direct to the surface; intersected by one or two diaphragms in each layer. Walls moderately thickened, composed, near the surface, of a dark ring of tissue immediately surrounding the cavities and a central lucid region (see fig. 3a). Mesopores few, generally small, situated mainly at the angles, often wanting over considerable spaces. A few small acanthopores present. Apertures angular or sub-circular, subequal, arranged in moderately regular curved rows, about 0.15 mm. in diameter, with nine in 2 mm.

The position of this species is doubtful. In many respects the Silurian genus *Leptotrypa* is suggested, but the presence of mesopores, argues against a reference to that genus. The mesopores again are sometimes arranged as in *Cyclopora fungia*, but the primitive portion of the zoœcia and the structure of their walls is different. The majority of the characters known point to the TREPOSTOMATA rather than to the CRYPTOSTOMATA, but till more material can be studied it has been deemed best to arrange the species as above.

Care must be exercised in separating the species from the laminar form of *Stenopora tuberculata* Prout, which occurs abundantly at the same locality. When the lower surface alone is visible, thin sections are generally required to distinguish them. They, of course, do so effectually.

Position and locality: Keokuk group. Warsaw, Ill., Greene Co., Ill., and Bentonsport, Iowa.

ADDENDA.

ISOTRYPA (? TECTULIPORA) GOTHLANDICA n. sp.

Pl. LIV, fig. 6, 6*c*.

Zoarium irregularly infundibular, about 2 cm. in height and the same in diameter at open upper end; base small. The zoarium consists of a double network; its entire thickness is about 1 mm. Zoœcial apertures on the outer side of the inner network, invisible from the surface because of the great development of the carinæ and scalæ prevailing in genera of this type, and which form the false or non-celluliferous outer network.

On the inner or "reverse" face of the zoarium the branches average a little less than 0.3 mm. in width, are flexuous, and seem to inosculate regularly, leaving oval fenestrules nearly as wide as the branches; 15 fenestrules, measuring longitudinally, in 1 cm.; 19 or 20 branches in 1 cm. transverely; surface of branches striate.

Obverse side with the carinæ very strongly developed, their summits expanded and connected transversely by scalæ, two-thirds as thick, at intervals equalling the development of the true dissepiments, which always occur almost directly beneath them. Outer surface of scalæ and summits of carinæ but little convex, and marked with from three to five distinct parallel lines, causing the two exposed faces of the zoarium to resemble each other greatly. The only difference likely to be noticed is that on the outer side the false fenestrules and branches are respectively a little larger and thinner than on the inner face.

Zoœcia in two flexuous ranges on each branch, one on each side of the carina, with 21 or 22 in 5 mm.; apertures subcircular, 0.1 mm. in diameter, with rather strong peristome.

Over the basal portion of the zoarium the false outer fenestrules are closed, and the entire space within apparently filled with vesicular tissue.

This species is closely allied to *Fenestella ambigua* Hall, from the Niagara shales of Indiana and New York. Its proportions, however, are somewhat smaller, there being only 10 fenestrules and 16 to 18 branches in 1 cm. in the American species. In the latter the outer or false fenestrules are also less regular.

The propriety of placing species of this kind with *Isotrypa* is questionable. If the presence of pores on the reverse side of the dissepiments is essential, and we are inclined to admit the point, then they must be placed elsewhere. Originally we intended to refer the two species to *Loculipora*, but since seeing figures of the types of that genus we have concluded that they cannot properly go there. *Unitrypa*, also, was suggested, but we believe that that name should be restricted to forms having the scalæ more numerous than the dissepiments. Hall's recently proposed *Tectulipora* (41st Ann. Rept. N. Y. St. Mus., 1888), is probably nearer the mark than any of those mentioned. The description, however, fails to fit the two species in one point, and that is in the statement that the carinæ continue over the dissepiments, thus leaving only perforations through the fronds and no median longitudinal channels. These exist not only in the Gotland species, but also in the Niagara and a Hamilton species from Michigan. As the point is one that is not easily determined, it is possible that the objectionable statement is founded upon faulty observation. Until more is known of the type of *Tectulipora*, and its character fully illustrated, we must be content with referring to the fossils under consideration as above.

Position and locality: Upper Silurian, Island of Gotland.

We are indebted to Prof. Gustav Lindström for the opportunity of describing this interesting species. The type is in the author's collection.

About the time the text of this volume had been put into type (Dec. 1st, 1889), Mr. S. A. Miller's valuable work on "North American Geology and Palæontology" appeared. A list of the new genera and species described in this volume had previously been transmitted to him, together with a revised catalogue and classification of American Palæzoic Bryozoa, which we had prepared, but could not, because of a lack of space, publish with the more necessary portion of our MS. on the Bryozoa. Mr. Miller, however, chose to arrange the Bryozoa according to his own views, adopting some of the new families, and nearly all the new genera and species. We do not complain of this, since he had an undisputed right to use the material turned over to him in whatever way he saw fit. We, on the other hand, have equally as good a right to dissent from the arrangement he has adopted, and we propose to exercise this right by offering the following critical notes on the more important points upon which our views deviate.

On page 169 he places the MONTICULIPORIDÆ and STELLIPORIDÆ under the sub-class ALCYONARIA, the first comprising the genera *Dekayia*, *Dekayella*, *Diplotrypa*, *Monotrypa*, *Monotrypella*, *Monticulipora*, *Nebulipora*, *Nyctopora* and *Prasopora*, while *Stellipora* alone is included in the second; and on the preceding page we find *Ptychonema* (Hall) under the sub-class *Zoantharia*, in the family CHETETIDÆ; on the whole an arrangement that is unwarranted, and in the last instance at any rate also misleading, since *Ptychonema* cannot be distinguished, upon any grounds known to us, from the earlier *Monotrypa*.

It is somewhat surprising to find *Nyctopora* (Nich.), a coral with relations to *Columnaria*, placed among the MONTICULIPORIDÆ. With the exception of this genus, all the genera referred by him to the family should be removed to the Bryozoa. If they are not Bryozoa, then the AMPLEXOPORIDÆ, BATOSTOMELLIDÆ, BYTHOPORIDÆ, CERAMOPORIDÆ, FISTULIPORIDÆ, HELIOTRYPIDÆ, PTILODICTYONIDÆ, RHABDOMESONTIDÆ, and TREMATOPORIDÆ, all of which Mr. Miller refers to the Bryozoa, are not either. Extensive comparative studies show beyond question that these are all so intimately related that they cannot possibly be divided into coral and bryozoan groups without doing actual violence to natural affinities.

As to *Stellipora* and *Constellaria*, which Mr. Miller considers as synonymous, they were placed already many years ago among the Bryozoa by such authorities as d'Orbigny and Jules Haime. A superficial comparison with Jurassic and Cretaceous

CERIOPORIDÆ (*e. g. Radiopora*) should suffice in showing that that is where they belong.*

On page 290 and 291, we find the classification into families adopted by Mr. Miller. We will review it in the alphabetical order in which he arranges the divisions.

The ACANTHOCLADIIDÆ include the same genera as on pages 397 and 398 of this volume, excepting that *Pinnatopora* Vine, is not recognized and *Glauconome* retained instead.

On pages 614 and 615 we give reasons for using Vine's genus instead of *Glauconome* for such species as we place under it in this volume. *Glauconome* can not be used for them for two reasons: (1) As originally defined in Goldfuss' work the name is synonymous with the previously defined *Vincularia* of Defrance. (2) If founded upon the emended definition by Lonsdale in Murchison's Silurian system, the type would necessarily be the *G. disticha* Lonsdale, which is a Wenlock fossil and probably quite different from the Devonian *G. disticha* of Goldfuss. An examination of a number of specimens of Lonsdale's species, which we owe to the kindness of Mr, Vine, has convinced us that the Wenlock species is totally different from those for which *Pinnatopora* is proposed. In fact they cannot belong to the same family, Lonsdale's *G. disticha* being closely related to *Nematopora* Ulr., and probably constitutes an extreme member of the *Arthrostylidæ*. Billings' *Helopora strigosa* is a congeneric species.

The AMPLEXOPORIDÆ is the same as in this volume, save that *Monotrypella*, a genus very closely related to *Amplexopora*, is out being placed with the MONTICULIPORIDÆ under the ZOANTHARIA.

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* Much evidence was published in Part I of our memoir on "American Palæozoic Bryozoa," (Jour. Cin. Soc. Nat. Hist. Vols. V, VI and VII), to establish the bryozoan nature of the Monticuliporoids. More still, and, among the latter probably some of the most important, was reserved to be drawn upon in case our views were criticised. But no call being made upon it, and the reserve being reinforced continually by new evidence gathered during the progress of our studies, we are now enabled to claim with confidence, that when the subject is again taken up by us, we will support our views with such an abundance of evidence that even the most skeptical of our opponents, provided he is just, must be convinced of their truth. The matter for the paper on the "Relations of Palæozoic to Mesozoic, Tertiary and Recent Bryozoa," has been ready for several years, and only awaits an opportunity when it may be published, properly supported by illustrations.

The ARTHROSTYLIDÆ and ASCODICTYONIDÆ also are constituted as in our classification, but under the BATOSTOMELLIDÆ we miss *Bythopora*, *Callotrypa* and *Stenopora*, the last being placed among the corals, and the second among the TREMATOPORIDÆ, while a new family, the BYTHOPORIDÆ, is proposed for the first. The family as given by him embraces besides *Anisotrypa*, *Batostomella* and *Leioclema*, also *Batostoma* (?) and *Peronopora*, the latter probably through a clerical error, since on p. 199, he places the genus as a synonym for *Monticulipora*.*

The BOTRYLLOPORIDÆ, including only *Botryllopora*, may be a good family. We did not feel warranted in proposing a new family and in our classification have doubtfully referred the genus to the FISTULIPORIDÆ.

The CERAMOPORIDÆ, however, is a heterogeneous assemblage. Thus, beside *Ceramopora*, *Ceramoporella*, *Chiloporella*, *Crepipora* and *Spatiopora*, which are properly referred here, the family is made to embrace *Eridopora*, *Glossotrypa*, *Lichenalia*, *Lichenotrypa*, *Odontotrypa*, *Pileotrypa* and *Selenopora*, all genera that, if not actual synonyms for *Fistulipora*, are at any rate so closely related to that genus that they must belong to the same family. None of them possess the structure characterizing the Ceramoporoids, while all have the vesicular interstitial tissue and zoœcial wall structure marking the Fistuliporoids.

Ceramella, an unquestionable synonym for *Glyptopora* and therefore a genus related to *Cystodictya*, (referred by Mr. Miller to the STICTOPORIDÆ) is also placed here, together with *Petigopora*, a genus whose minute structure agrees intimately with *Dekayia*, which, as we have seen, he puts with the ALCYONARIA. *Sagenella*, founded upon a species, that if it is not strictly a *Berenicea*, clearly belongs to the TUBULIPORIDÆ and *Phractopora*, the relations of which are uncertain and which he also refers to the STICTOPORIDÆ, complete the list of genera placed by him as CERAMOPORIDÆ.

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*It is interesting to note how differently authors view the Monticuliporoid divisions proposed by Nicholson. Contrast with the above Waagen and Wentzel's recent erection of the subfamily *Peronoporinæ* (Pal. Indica, Ser. XIII, I, 6.)

The erection of a new family for *Crisinella* may be justifiable in a work of that kind; but not so the ENALLOPORIDÆ, under which he ranges *Diploclema*, *Enallopora* and *Protocrisina*, since the ENTALOPHORIDÆ will include these genera without any extension of its usually accredited limits. We must protest also against the use of d'Orbigny's *Enallopora* instead of our *Mitoclema*. *Enallopora* was founded upon Hall's figures and description of *Gorgonia* (?) *perantiqua* (Pal. N. Y. Vol. I, 1847.) Mr. Miller gives the following free translation of d'Orbigny's description (Prodr: d. Pal. T. 1, p. 22, 1850.) "Small bifurcating branches, without connecting bars; cell-mouths prominent on each side, opening laterally and alternately." How can this description be made to include *Mitoclema cinctosum*, in which cylindrical stems are encircled by transverse rows of zoœcial apertures as in *Spiropora* and *Enthalophora!* Nor are we acquainted with any bryozoan from the Trenton rocks having two rows of alternately arranged and outwardly projecting cell-apertures. The species which we originally identified with Hall's *G.* (?) *perantiqua* (Jour. Cin. Soc. Nat. Hist. Vol. V, p. 159,) since it was found to agree neither with the description nor with the figures given by Hall of that species, is now described as new and made the type of the new genus *Diploclema*, a subsequent and more careful examination having developed that we were wrong in uniting the species with *Mitoclema*.* We have also become convinced that Hall's work on his *Gorgonia* (?) *perantiqua* is faulty and that *Enallopora* rests upon characters that are hypothetical and with no existence in nature. If this view is right, then *Enallopora* cannot stand, since it fails to fulfill the first and most important rule of nomenclature in this *that the description is not sufficient for the identification of the organism named.* And there is no rule known to us permitting the retention of a genus founded upon *imaginary* characters.

His FENESTELLIDÆ embraces all the genera placed there by us save *Thamniscus*. D'Orbigny's very doubtful *Reteporina*, and

* For further remarks upon this subject see note under *Protocrisina exigua* (p. 405) which is another of the forms that have been identified with Hall's species.

Clathropora, *Coscinella*, *Coscinium*, *Coscinotrypa*, *Evactinopora*, *Reptaria* and *Semiopora* are also included.

Upon what grounds the last seven genera are placed into the same family with *Fenestella*, etc., is beyond our comprehension; and we are thoroughly satisfied that no one who has paid even the most cursory attention to fossil Bryozoa, will follow him. *Clathropora* differs from *Ptilodictya* only in its mode of growth, and *Coscinella* and *Coscinium* are distinguished from *Intrapora* and *Cystodictya* in precisely the same manner. In their internal and really essential structure each pair of these genera is practically identical. *Coscinotrypa* Hall, is a pure synonym for *Coscinium*,* while *Semiopora*, as defined and figured by Hall, (Pal. N. Y. Vol. 6, 1887,) is indistinguishable from *Phænopora*.

Evactinopora also, though regarded by us as a very good generic group, is distinguished from *Glyptopora* and the other genera comprised in our CYSTODICTYONIDÆ, almost solely by characters resulting from its peculiar style of growth. The zoœcial features are essentially the same in all, constituting the CYSTODICTYONIDÆ one of the most natural and easily recognized families of Palæozoic Bryozoa. We were, therefore, not a little disappointment at finding that the family was not adopted by Mr. Miller. In splitting up the family and re-distributing the genera he has been very unfortunate, especially in placing one among the CERAMOPORIDÆ and several with the FENESTELLIDÆ. The remainder he puts with the STICTOPORIDÆ which is a less unreasonable allocation.

Rcptaria also, surely has nothing in common with the *Fenestellidæ*, and, if it is a bryozoan at all, must go with *Hederella* into the *Cyclostomata* near the *Tubuliporidæ*.

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*It should be remarked here that Mr. Miller regards *Glyptopora* Ulr., (erroneously written *Glyptotrypa* by him) as not distinct from *Coscinium* Keyserling, and that he has apparently overlooked the new species of *Glyptopora* described in this volume. He gives no reasons for thus ignoring our genus, and it is a little surprising to find that he has not emended the definition of *Coscinium* so as to cover *Glyptopora*, but leaves it so that its terms include only the cribriform species for which Keyserling proposed the genus and for which the name was adopted by Hall, Ulrich and others. On the other hand he accepts Hall's *Coscinotrypa* for *Coscinium cribriforme* wh ch we, in accordance with the anthor of the species, regard as one of the most typical species of Keyserling's genus. Such a proceeding does not appear just to us. We may add further that the characters which he assigns to *Coscinotrypa* ought to be joined to his description of *Coscinium* to make it complete.

The FISTULIPORIDÆ as recognized by him contains besides those genera that we place there, also *Actinotrypa*, *Callopora*, *Calloporella and Callotrypa.* In his definition of the first of these genera (p. 291,) the only feature mentioned as distinguishing it from *Dichotrypa*, which he places among the STICTOPORIDÆ, are the radial striæ that extend down the vestibular portion of the zoœcial aperture in *Actinotrypa.* And yet the two genera are placed into different families. It is now a well established fact that *Callopora* is without the interstitial vesicles which characterize the FISTULIPORIDÆ, and, therefore, ought not to belong to the same family. The same is true of *Calloporella* and *Callotrypa,* but the latter has the structure of the BATOSTOMELLIDÆ, its systematic position being intermediate between *Bythopora* and *Leioclema.* He also places in this family (the FISTULIPORIDÆ) *Eridopora*, *Lichenotrypa* and *Selenopora,* a reference that we believe correct, at any rate more so than under the CERAMOPORIDÆ, where they also occur.

The HELIOTRYPIDÆ includes, as in our work, only the genus *Heliotrypa.* But why is this genus also placed with the STICTOPORIDÆ as we will see presently?

The next family is the LABECHIIDÆ, with one genus, *Labechia* Ed. & H. Mr. Miller himself seems to have doubted that this genus belongs to the Bryozoa, since on p. 310, he supplements his definition with this remark: "Probably this genus belongs to the Protozoa and is related to the Sponges." We were not aware that anyone doubted that *Labechia* is an unequivocal Stromatoporoid, and consequently far removed from the Bryozoa.

The PALESCHARIDÆ and PHACELOPORIDÆ include as with us each only its typical genus.

Under the PTILODICTYONIDÆ, however, he has struck out *Clathropora*, *Arthropora*, *Intrapora*, *Semiopora* *Stictoporella* and *Tæniodictya*, all of which, except the first and fourth, that, as has been stated already, he refers to the FENESTELLIDÆ, he places with the STICTOPORIDÆ, a course that is unwarranted if we credit zoœcial features with importance in the framing of our classifications. Furthermore, our family STREBLOTRYPIDÆ is set aside and the five genera *Cyclopora*, *Cycloporella*, *Proutella*, *Streblotrypa* and *Worthenopora*, which, with us constitute that division, are removed to this family, a proceeding for which there is even less reason than in the preceding case. In fact the STREBLOTRYPIDÆ is one of the best marked families of Palæozoic Bryozoa, resembling the PTILODICTYONIDÆ much less than do the STICTOPORIDÆ and some of his FENESTELLIDÆ. A union with the RHABDOMESONTIDÆ might have been comprehended and perhaps excused by us, since that family embraces some of its nearest relatives. *Coscinella*, we believe, is properly placed in the family, but he has also put the genus with the FENESTELLIDÆ, while *Intrapora*, to which *Coscinella* is very nearly related, is found among the STICTOPORIDÆ.

The RHABDOMESONTIDÆ is constituted as in this volume, only *Anisotrypa* belongs with the BATOSTOMELLIDÆ, where he has also placed it.

The RHINOPORIDÆ and SPHRAGIOPORIDÆ embrace as in this work only the typical genera.

STICTOPORIDÆ.—In this family he places, besides the genera that we refer there, also *Acrogenia*, *Cystodictya*, *Dichotrypa*, *Phractopora*, *Prismopora*, *Scalaripora* and *Tæniopora* which with us form the bulk of our CYSTODICTYONIDÆ; also *Arthropora*, *Intrapora*, *Stictoporella* and *Tæniodictya*, which we refer to the PTILODICTYONIDÆ on zoœcial characters mainly; and *Heliotrypa* which, a little higher on the page, he makes the type and only genus of the HELIOTRYPIDÆ.

His family SUBRETIPORIDÆ is in every way equivalent to our PHYLLOPORINIDÆ, he being of the opinion that *Phylloporina* Ulr., is the same os *Subretepora* of d'Orbigny.

This is a case very nearly like that between *Mitoclema* and *Enallopora*, discussed above. D'Orbigny proposed *Subretepora* for Hall's *Intricaria reticulata*, relying upon Hall's description and figures (Pal. N. Y., Vol. I) for the characters of his genus, which he defines as having a single row of large cells, occupying the entire width of the slender, irregularly anastomosing branches, all of which agrees very well with the data upon which he relied. Now, however, since it is known that Hall's diagnosis and figures are incorrect in precisely those features upon which d'Orbigny founded the genus, it is evident that *Subretepora* must drop out of sight once more, on the ground of insufficient and incorrect definition. According to our view, it is neither safe nor proper to found genera upon someone else's figures or descriptions, particularly if these were drawn or written in the '40s, when palæontological work was not done nearly so accurate as is now demanded. Nor can we regard it as good policy to resurrect old and obscure names, especially when they, like those under consideration, have never been current in palæontological literature. Indeed, so far as we are informed, none of the genera of Bryozoa proposed by d'Orbigny for species described by Hall in Vol. I, of the New York Reports on Palæontology, have been used by subsequent writers. They do not even appear in catalogues like Bigsby's "Thesaurus Siluricus." *Enallopora*, *Subretepora*, and *Sulcopora* (founded upon Hall's *Stictopora fenestrata*, which, for the present we regard as the type of *Stictopora*), were known to us since March, 1880, but we placed them, in accordance with what seemed to be common consent, among the "not recognized" names.

The THAMNISCIDÆ, including *Crisinella*, *Diplopora*, and *Thamniscus*, is not a natural assemblage. Nor does Mr. Miller appear to have had much faith in the group, since *Diplopora* occurs among the genera of his ACANTHOCLADIIDÆ, and *Crisinella* is the type of his CRISINELLIDÆ. *Thamniscus*, the only genus remaining is, as we have shown on pages 357 and 606 of this volume, too clearly related to *Polypora* to permit of greater than generic separation.

The TREMATOPORIDÆ includes a very peculiar and unnatural assemblage of genera, showing in a striking manner the inconsequence of those authors who deny that *Monticulipora*, *Monotrypa*, *Stenopora*, etc., are Bryozoa. Thus, Mr. Miller places here besides *Acanthoclema*, *Bactropora*, *Nemataxis* and *Tropidopora*, which he has arranged much more properly also with the RHABDOMESONTIDÆ; and *Amplexopora* and *Atactopora* which the reader will find also under the AMPLEXOPORIDÆ; and *Chilotrypa* which has been already correctly placed with the FISTULI-

PORIDÆ; *Atactoporella*, *Homotrypa* and *Homotrypella*, three genera closely related to *Monticulipora* and quite distinct from *Trematopora; Diamesopora*, a Ceramoporoid and totally different from *Trematopora*, as founded upon *T. tuberculosa;* and *Nicholsonella*, which of all the genera placed here by Mr. Miller alone belongs to the same family as *Trematapora*, *Orthopora* being a pure synonym for *Rhombopora*, and *Trematella*, most likely, the same as *Batostomella*.

The TUBULIPORIDÆ we find no fault with save in this, that *Sagenella*, which he has with the CERAMOPORIDÆ, ought to go here, because, if indeed it is not a straight synonym for *Berenicea*, they are at any rate very nearly related.

INDEX TO VOLUME VIII, PART I.

(Species marked † are figured in the text.)

ERRATA IN PART I.

Page 42, line 3 from bottom, for 100.04 read 100.14,

Page 49, line 11 from bottom, for 528-6 read 628-6.

Page 62, line 19 from top, for 1,088 read 1,078.

The Hillsboro boring log, on pages 46 and 47, bearing various evidences of incorrectness, I wrote to Mr. GEO. C. BRYCE, who kindly furnished me the following corrections:

	Ft.	In.
11 Limestone (Shoal Creek)	..	8
15 Sandy shale and sandstone	63	4
22 Limestone	..	6
25 Clay shale	1	10
27 Bituminous shale	..	6
35 Coal, 1 ft.; slate, 6 in.; coal, 1 ft. 6 in.—No. 5	3	..
Total depth	775 feet.	

(J. L.)

INDEX TO VOL. VIII, PART II.

SECTIONS 1 AND 2.

(Numbers in Full Face refer to diagnosis. An asterisk (*) after the number of the page indicates that the species is figured.)

ERRATA IN PART II, SECTIONS 1 AND 2.

On Page 74, change Z. PELLAENSIS to Z. PELLENSIS.

On Page 75, change Z. CARINATUS to Z. CARINATA.

On Page 76, change Z. LANCEOLATUS to Z. LANCEOLATA.

On Page 78, change Z. CYLINDRACEUS to Z. CYLINDRACEA.

On Page 80, change *Z. cylindraceus* to *Z. cylindracea.*

On Page 80, change A. IOVAENSIS to A. IOVENSE.

On Page 116, after *A. providensis*, Cox, sp. insert (Pl. XXI, figs. 4, 4a.)

On Page 136, change Pl. XXIV, Fig. 2 to Pl. XXIV, Fig. 5.

On Page 138, change PEUROTOMARIA IOWENSIS to PLEUROTOMARIA IOVENSIS.

On Page 143, change M. ALTONENSIS to M. ALTONENSE.

On Page 207, line 4 from bottom, leave out the word large before plates.

On Page 207, line 3 from bottom, change smaller to larger.

INDEX TO VOL. VIII, PART II.

SECTIONS 3, 4 AND 5.

(Numbers in Full Face refer to pages where diagnosis or description is given. An asterisk(*) after a number indicates that the species is figured.)

ERRATA AND ADDENDA.

PART II, SECTIONS 3-5.

Page 211, to the list of genera at the bottom of this page, add: *Receptaculites* by Defrance; *Ischadites* by Murchison; *Cerionites* by Meek & Worthen.

Pages 218, 222, 235 and 250, the name *Syringophyllum*, being pre-occupied, should be changed to *Syringelasma*.

Page 218, line 18 from bottom, for *Sollacia* read *Sollasia*.

Page 221, in foot note, for *Stromap toroidea* read *Stromatoporoidea*.

Page 233, line 2 from bottom, for 1880 read 1889.

Page 235, line 2 from top, for A. mamillata read A. mammulata.

Page 235, line 10 from bottom, for C. radialis read C. radiata.

Page 257, line 10 from bottom, for the systems read the canal systems.

Page 272, line 17 from top, for U. & R. read U. & E.

Page 273, line 17 and 18 from bottom, exchange former and latter.

INDEX TO VOL. VIII, PART II.

SECTION 6.

Numbers in Full Face, indicate page where diagnosis or description is given. A cross (†) indicates that an illustration is given in the text. An asterisk (*) indicates that an illustration is given on the plates.

ERRATA IN SECTION 6.

Page 320, 3d line from top, for *occellata* read *ocellata*.

Page 320, 6th line from bottom, for *cribriformi* read *cribriforme*.

Page 321, 10th line from bottom, for *hili* read *hilli*.

Page 324, 16 and 17th line from bottom, for *Fenestrella* read *Fenestella*.

Page 335, 18th line from bottom, for exert read exsert.

Page 344, 8th line from bottom of note, for of Joredale read on Yoredale.

Page 350, 10th line from bottom, for secton read section.

Page 357, 16th line from top, for geneo- read genea-

Page 358, 2d line from bottom, for biserialis read biseriata.

Page 366, 9th line from top, for *Intrapora basalis* read *Stictoporella basalis*.

Page 368, in note at bottom, for Rolle read by Rolle.

Page 369, 12th line from top, for exerted read exserted.

Page 394, in explanations to fig. 14, transpose *a* and *b*.

Page 394, 11th line from bottom, for *Cosinella* read *Coscinella*.

Page 397, 3d line from top, for *Schumardi* read *Shumardi*.

Page 420, 10th line from bottom, for Pl. XXXIV read Pl. XXXVIII.

Page 453, 2d line from top, for Pl. XLIV read Pl. XLVI.

Page 469, add the following note, *Chœtetes venustus* Ulr., Journ. Cin. Soc. Nat. Hist. Vol. 1, p. 93, Pl. IV, fig. 7, 7*a*, 1878. (This note, in part, occurs erroneously on page 470.)

Page 489, 19th line from bottom, for Pl. XLVII read Pl. XLVIII.

Page 492, 4th line from bottom in note, for *fenestruta* read *fenestrata*.

Page 515, 19th line from top, for fig. 4 read fig. 7.

Page 527, 11th line from bottom, for fig. 1-1b read 1-1t.

Page 532, 3d line from bottom, for fig. 5-5b read 5-5c, and add, Pl. LXVIII, fig. 5, 5a, and LXIX. fig. 2, 2a.

Page 578, 14th line from bottom for place read space.

Page 600, 9th line from bottom for *P. eximia* read *P. whitei*.

Page 610, 6th line from bottom, for var. SEVILLENSIS read THAMNISCUS SEVILLENSIS; and modify the description and remarks so that they will accord with this change.

Page 620, 14th line from top, for XLVI read LVI.

Page 623, 2d line from top, for figs. 5-5c read 5-5b.

Page 643, in explanation to fig. 18, for fig. *a* read *c*; for *c* read *d*; for *d* read *e*; for *e* read *a*

Page 647, 3d line from top, for 0.2 mm. read 2 mm.

Page 653, 15th line from top, for fig. 1-1b read fig. 1-1f.

TABLE OF CONTENTS.

SECTION 6.

APPENDIX.

(Geological Survey of Illinois, Vol. VIII.)

THE PRIVATE LIFE

AND

SCIENTIFIC WORK

OF

PROF. AMOS HENRY WORTHEN.

BY

N. W. BLISS AND CHARLES A. WHITE.

WITH A PORTRAIT BY JACQUES REICH.

No. 6646 Wentworth Avenue,
Englewood, Ill., December 22, 1888.

Prof. Josua Lindahl, *State Geologist,*
Springfield, Ill.:

Dear Sir—In response to your request that I should prepare for the Eighth and final volume of Prof. Amos H. Worthen's Reports upon the Geology of Illinois, a biographical notice of the learned and lamented author, I beg to submit the enclosed account of his life and estimate of his personal and scientific character; and to remain, most truly,

Your obedient servant,

N. W. Bliss.

A Sketch of the Private Life and Personal and Scientific Character

OF

PROF. AMOS HENRY WORTHEN.

BY N. W. BLISS.

Prof. AMOS HENRY WORTHEN, State Geologist of Illinois and Curator of the State Historical Library and Museum of Natural History, died at his home in Warsaw, Hancock county, Illinois, on Sunday, May 6, 1888, of pneumonia, at the ripe age of nearly seventy-five years. For over thirty years he had been constantly engaged, first, in the survey of, and then in writing and publishing the reports upon, the geology of his great adopted State; and his work has been of such a thorough and able character, that while it has made for him a name honored among the scientists of the world, his volumes have long been text books of palæontological nomenclature. Just prior to his death he had completed and prepared for publication his eighth and final volume of Reports upon the Geology of Illinois, and was anticipating a period of rest as soon as by means of a suitable appropriation this final volume should be published and off his hands, having determined then to resign the place in the service of the State which he had so long and ably filled. But death came all too soon and found the busy man still in harness, and the period of earthly activity was exchanged for one of heavenly rest.

Amos Henry Worthen was born at Bradford, Orange county, Vermont, October 31, 1813. He was the son of Thomas Worthen and Susannah Adams, his wife, and was the youngest, save one, of a large family of thirteen children. His mother, Susannah Adams, was the daughter of Abraham Adams, who married Mary Brickett, and was a descendant of Henry Adams, the founder of the Adams family in America, who settled at Mount Wollaston (now Quincy), Massachusetts, and to whose memory his descendant, President John Adams, erected a plain granite monument with this quaint inscription:

"In memory of Henry Adams, who took his flight from the dragon persecution, in Devonshire, England, and alighted with eight sons near Mount Wollaston. One of the sons returned to England after taking time to explore the country. Four removed to Medford and the neighboring towns. Two to Chelmsford. One only remained, Joseph, who lies here at his right hand, who was an original proprietor in the Township of Braintree, incorporated in the year 1639."

Susannah Adams, the mother of Prof. Worthen, was a woman of a most amiable disposition, and at the same time of great mental and physical activity and force. A mother with these characteristics seldom fails to transmit them to her posterity. His father, Thos. Worthen, was the owner of a farm upon what was known as the South Road, in Bradford, where were "brought up" (not "raised") this large family of sons and daughters. Here Prof. Worthen gained the first rudiments of his education in the excellent common schools of his native State, and his early physical training, of almost equal importance to his future usefulness in his chosen profession, in labor upon his father's farm. At that time the academy at Bradford Village was an institution of learning of a high class, and here Prof. Worthen finished his school training, boarding for that purpose at the home of his sister, Mary, who married Capt. Ellis Bliss, an extensive farmer in the Connecticut Valley. Attending the same school, from the same house, bearing the relation of uncle and nephew, he finishing, and the writer beginning his academic course, a friendship and intimacy began which lasted from that period to the day of his lamented death. At an early age, before arriving at his majority, he married, January 14, 1834, Miss Sarah B. Kimball, of Warren, N. H., who was his faithful and life-long companion, preceding him to the better land only a little over a twelve-month. At that time Ohio and Kentucky were the far west, and it required a high degree of courage and determination for the young New Englander to risk his fortunes in those strange and distant lands. But, as with so many others, Prof. Worthen was not without friends and even relatives in the distant west. His eldest brother, Enoch, was then living at Cynthiana, Kentucky, where he had settled and founded a family, and thither the young emigrant betook himself. Whatever else the average New Englander may or may not be capable of doing, one thing, for want of better, or rather more remunerative employment, they have almost universally engaged in, in all the new countries which they have helped to settle and civilize, and that is, school teaching. Prof. Worthen, then a plain Yankee lad, without title, was no exception to the rule, but began his western life and experiences in teaching school at Cumminsville, Ohio, then in the wilderness—though now a suburb of her chief city, Cincinnati. Remaining here two winters, in June, 1836, he took his wife and infant son to Warsaw, Illinois, where he made his permanent home. Here he has done his life's work, and hence he has entered into (well earned) rest. Meanwhile his wife's family (the Kimballs) had also emigrated to the west, making their home on Bear Creek, in Hancock county, and with his brothers-in-law, the Kimball boys, or one of them, Prof. Worthen became first a forwarding and commission merchant, occupying and residing in the warehouse and dwelling standing on the site now occupied by the mill of the Warsaw Milling Company, known as Grace mills, later occupying the brick cottage which he built, and conducting a dry goods business upon the hill at Warsaw. In 1842, influenced by the depression in business caused by the Mormon difficulties in Hancock county, he removed with his family to Charlestown, Mass., and here his son, Amos Henry Jr., was born. He was probably influenced in his second removal (that from Ohio) to select Warsaw as his future home, by the fact that his wife's family had selected this region as their western home, but had his predilections for the life of a naturalist been known and their stimulation anticipated, no region could have been selected better calculated to awaken and sustain the enthusiasm of a naturalist. As stated by himself on page 89 of his first volume of Reports upon Geology of Illinois: "A fine section of the geode bed is exposed just above the steamboat landing at Warsaw, where its whole thickness may be seen in the bluff above the railroad grade, and there is perhaps no locality known in the west where a few hours labor of a good collector would be rewarded by so large a variety of finely crystallized specimens. There is no formation in the State that presents such attractive and interesting specimens of crystallized minerals as are to be found in this division of the Keokuk limestone, and tons of these beautiful geodes have been sent from the county of Hancock to adorn the cabinets of mineralogists throughout the civilized world." It may be added that by far the largest portion of these shipments have been sent abroad by Prof. Worthen himself. One can easily imagine what an impetus such surroundings would give to a love of nature already abounding, and to powers of observation and analysis already somewhat trained and cultivated by study and travel, accordingly his attention from the first was strongly attracted to the geological features of his new home, and its geode beds at once commanded his admiration and close investigation. Even at that early period he felt stirring within him that spirit of investigation and love for natural science that later caused him first to neglect and then to abandon entirely all business less suited to his taste, and to devote himself to science with a singleness of purpose and devotion as rare as it is honorable to the individual and advantageous to mankind. He gathered and took with him to Boston several barrels of the splendid crystallizations called "geodes," then rare in collections, and there, instead of selling them, with a naturalists true love for his (to be) calling, exchanged them for a cabinet of sea shells, which he brought back with him to Warsaw when he returned there in July, 1844.

Similar forms to these shells he saw everywhere preserved in the limestone rocks and shales of his neighborhood and every spare hour found him with his hammer and satchel exploring every ravine, bluff and quarry and every exposure of the subjacent rocks which could be reached. He was consumed with a desire to know something of their history and nomenclature. The science of geology may be termed a child of the nineteenth century, during which more progress has been made in the knowledge of the history of the earth than during all preceding time. When Prof. Worthen took up the study, amid the cares of a family and while engaged in business, the facilities for its study were extremely few especially in the western country. No work on elementary Geology had then been published in this country and the first books that he was able to obtain were Dr. Mantell's "Medals of Creation" and "Wonders of Geology," which I well remember finding in his library upon my arrival at his house in the spring of 1850. They were written in a style adapted to popular comprehension and by as great an enthusiast and collector as himself. It is doubtful if any works could be found now, better calculated to stimulate the zeal of a born naturalist. They presented a general survey of the Fossil World, with an outline of British Palæontology, illustrated by wood cuts of fossil remains. It gave him what he most needed at the time, an insight into the manner in which the sedimentary rocks were formed and how the remains of animals and plants came to be embedded and preserved in them. By collecting the minerals and fossils in his own locality and exchanging them with other collectors for those found elsewhere, he gradually gathered not only an extensive and very valuable geological museum but acquired the knowledge which was the object of his ardent pursuit. Thus the writer found him upon his own arrival in the Mississippi Valley in the spring of 1850. He was still engaged in business but his store as well as his house was more of a stone shop than a dry goods shop and he evidently begrudged the time there spent waiting for or attending upon customers; consequently he soon sold out his business and determined for the future to devote himself to his loved science. Meanwhile by his correspondence and exchanges he had made the acquaintance of many men engaged like himself in scientific pursuits and made such progress himself in knowledge as to be elected a member of the American Association for the Advancement of Science at its 5th annual meeting, held at Cincinnati in 1851, a society of which he remained a member to the time of his death, whose proceedings he greatly enjoyed, and to whose transactions he at various times contributed valuable papers, notably "On the occurrence of fish remains in the carboniferous limestone of Illinois", "Remarks on the discovery of a Terrestrial flora in the Mountain Limestone of Illinois," and "Remarks on the relative age of the Niagara and the so-called Lower Helderberg groups."

January 16, 1863, Prof. Worthen was made a member of the "American Philosophical Society of Philadelphia."

October 15, 1871, he was appointed correspondent of "The Imperial Royal Geological State Institute of Vienna."

April 17, 1872, he became a member of the "National Academy of Sciences, U. S. A." And on May 20, 1873, of the "Societé Royale des Sciences de Liège."

He was probably a member or correspondent of other learned scientific bodies, but he was careless of such honors, paying more attention to furnishing the scientific world through the membership of these societies, with new facts and discoveries, than to receiving from them indorsements or honors. Before these scientific bodies he read or to them he communicated at various times, important papers relating to his investigations and discoveries in the Lower Carboniferous Limestones, some of which will be found published in the transactions of the St. Louis Academy of Sciences, of the American Philosophical Society of Philadelphia and in the American Journal of Science and Arts, edited by Silliman, specimens of these communications are found in his remarks on the age of the Leclaire Limestone, at Leclaire, Iowa, and Port Byron, Illinois, Vol. 33, Silliman's Journal, and Remarks on the Age of the Goniatite Limestone at Rockford, Indiana, Vol. 32, Silliman's Journal, a joint paper by himself and the learned palæontologist Prof. F. B. Meek, whom he had so closely associated with himself in the Palæontology of the Illinois Survey.

Prof. Worthen was not given to "rushing into print" and except for the purpose of preserving priority of description and nomenclature of the fossils collected and described in the reports of the Illinois Survey, seldom published anything unless he had some important fact or discovery or well considered conclusion, to present to the scientific world.

The Illinois Legislature in February, 1851, passed an act authorizing a geological survey of the State, appropriating \$3,000.00 a year for that purpose, and two years later increased this appropriation to \$5,000.00 per annum. Prof. Norwood, a

Scientist of repute, who had been associated with the noted Scientist Prof. Owen, of Indiana, was appointed Geologist, and for a while Prof. Worthen did some work under him, but soon engaged in more active work in Iowa under Prof. James Hall of New York, who having just finished the survey of his own great State was called to that of Iowa, which State had, in 1855, passed an act authorizing a survey which was promptly commenced in September of that year. Prof. Hall in his first report says of Prof. Worthen that "he was engaged as assistant at the commencement of the survey and was employed during the seasons for exploration until the close of 1857; by his services in the field and the loan of his magnificent collection of carboniferous crinoids he has added greatly to the value and interest of this report."

His first work here was a series of examinations along the DesMoines Valley and the eastern border of the Iowa coal field made with a view of determining the number, thickness and relative value of the different coal seams outcropping in that part of the State, upon which he duly reported and the next year (1857) he made minute examination of and report upon the geology of certain counties in southeastern Iowa. This constituted all the detail work of that survey, only the leading features of the remaining counties establishing the outlines of their geology being given.

Meanwhile the work in Illinois languished; although six years had elapsed since the passage of the act authorizing the survey, no report had been made, and when on March 22, 1858, Gov. Wm. H. Bissell placed in the hands of Prof. Worthen his commission as State Geologist, nothing of prior work came to his hands save a report by Prof. Norwood on the lead mines of Hardin county, and the field notes of his assistants. On taking charge of the survey Prof. Worthen at once proceeded to those active labors in the field, in prosecuting which he has probably carried a greater bulk and weight of geological specimens than any other scientist of his day. During his long period of preparation by personal exploration and study of the geological formations of his vicinity and by the extensive system of exchanges he established with other collectors at an early day, he had been enabled to gather, classify and arrange the largest and best geological museum in the west. By his minute and careful examination of the rocks of his region he had discovered those "platforms of death" as he well named those crowded masses of remains of fossil fishes which he found in the thin strata of the lower Archimedes limestone. One specimen found by him in this prolific locality proved to Prof. Agassiz that he was correct in his conclusions already drawn from comparative anatomy, and he stated that it enabled him as upon an established basis of fact (not reasoning) to take up his studies of fossil fishes anew and pursue them further than ever, and he had portions of this collection long in his possession. This minute and careful personal examination and observation of the different strata and abundant collection of specimens redounded greatly to the advantage of his collection which consequently contains a greater number of what may be called type-specimens than any other collection. From it were selected almost wholly the specimens with which to illustrate the reports upon Palæontology of Iowa and the same is largely true also of the volumes of the Illinois reports. He had also during these years gathered together a scientific library of great value. The writer well remembers how he exercised a severe economy in other directions to enable himself to purchase the rare and expensive books needed for his studies in his favorite field. Wherever a book was to be had in exchange for specimens it was obtained regardless of expense in the way of payment for it, and where money was required it was freely expended. Thus well equipped, both by personal experience in the field, and by the study of actual specimens as well as of books, he came to his life work of which it is enough to say that it has been done with characteristic thoroughness and fidelity, and reported with an ability and minuteness that have made his reports text books of the Palæontology of Illinois, and a monument of his own industry and ability. Professor Worthen like General Grant, never withheld the meed of praise and credit from his assistants and co-laborers. He had the countenance, support and friendly aid of numerous lovers of science in all parts of the State. He also secured for the work the aid and assistance of the ablest specialists of the day in every department, notably Prof. J. D. Whitney in mineralogy, Prof. Leo Lesquereux in coal measures and coal plants, Profs. F. B. Meek, Orestes St. John, Dr. John S. Newberry and Mr. E. O. Ulrich in different departments of Palæontology, Dr. J. V. Z. Blaney in analysis and Mr. Henry Engleman in chemistry and detailed county work.

There were born to Prof. Worthen and his wife Sarah, six sons, all of whom survive him, and one daughter, whose death in early years was mourned during their whole lives. He had a happy and prosperous home and the companionship and support of a faithful and noble wife. All the sons are worthily married and twenty-two grand children are growing up in the light and succession of an honorable name. The six sons, Fay S., George B., Thomas A., A. H. Jr.. Charles K. and John B. were their honored fathers's pall-bearers, and by them were his remains placed in the tomb at Oakland Cemetery at Warsaw. All are residents of Warsaw save Fay S., who, since his father's death, has removed to Denver, Colorado. As was natural in a family where the head was so entirely devoted to scientific observation, all the sons and some of the grand-children as well became imbued to some degree with the father's enthusiasm and in all of them the powe and practice of close observation of nature and natural objects, is developed to an unusual degree. One of them, Charles K., has devoted himself to natural science and is now a naturalist and taxidermist of note residing at Warsaw. He it was, who made the fine pencil sketches for the engraver, which have given the numerous volumes of the Illinois survey their admirable illustrations.

Mr. Edward O. Ulrich, formerly one of his assistants in the Illinois survey, says of him, "Prof. Worthen's labors related principally to the carboniferous series. To him belongs the credit of being the first to work out the true relations of the principal divisions of the lower carboniferous system, though the inflexible rules of priority may demand that the names proposed by other laborers in this field should stand for them."

"The value of his work was recognized by his election as an honorary member of several European scientific societies as well as a membership of various scientific societies in his own country."

Regarding his character; Prof. Ulrich who had an unusually good opportunity to form a sound opinion, says, "Its salient features were: great love for scientific truth and justice, simplicity, unbounded affability, unswerving integrity, coupled with an unpretentious yet strong desire to accomplish a useful career. His generosity and charity scarce knew bounds, while in his public and private life his frank and sympathetic nature and unassuming yet dignified demeanor won the esteem of all with whom he came in contact.

This seems to me, having known him all my life, an estimate at once terse and just.

Like Dr. G. A. Mantell, the author of the first works on Geology, Prof. Worthen was able to obtain, "his most important discoveries sprang out of the researches he never ceased to pursue among his favorite group of rocks—the Lower Carboniferous. His location at an early period of his professional career, was exceedingly favorable for these inquiries, and as stated by Prof. Ulrich he was assuredly the original demonstrator of the true relations of its principal divisions. With the Lower Carboniferous series also are connected his chief and very memorable palæontological discoveries, out of that formation he procured those wonderful fish remains so highly regarded by Prof. Agassiz as well as the evidences of Terrestrial Flora there imbedded as announced in his paper read before the 13th meeting of the American Association for the advancement of science.

I feel that I cannot close this biographical notice of Prof. Worthen without calling attention to characteristics that, to my mind, rendered him a brother indeed to that great naturalist he so much admired and loved, Prof. Agassiz. He had the same intense love of natural science with that great teacher. Like him, he could not exist without collecting a museum. He had the same remarkable powers of instant observation. Like him, he gathered and brought home from the formations to which he devoted his life work a greater variety and collection of fossil remains than have ever before or since been collected by one individual. He had the same disinterestedness, the same consecration to science, the same readiness to oblige even the humblest and most modest, the same superiority to self-interest, the same sincerity and absence of all pretension, and the same enthusiasm in all that was noble. As with Agassiz, so with Worthen, never was a life more richly filled with study, work and thought. Like Agassiz, Worthen had no time to make money.

In one of his letters home, Agassiz said: "If I could for a moment forget that I have a scientific mission to fulfill I could easily make more than enough by my lectures to put me completely at my ease, but I will limit myself to what I need to repay those who helped me through a difficult crisis. Beyond that all must go to science—there lies my true mission."

So said Prof. Worthen in deed, if not in words. I well remember his only anxiety for money was to pay some balances on his mercantile debts, and these he paid out of his salary earned in his early employment in geological surveys, and as with his great exemplar, all beyond that "went to science." As said by me in the obituary notice of him published in the Warsaw (Ill.) Bulletin just after his decease, Prof. Worthen was, like most men who become eminent in any special work, entirely devoted to that work, and counted all else as dross in comparison with results to be obtained in his favorite field of investigation, and the result with him, as with such men in all ages, has been a long, honorable, industrious and useful life, and an honored and lamented death.

A Sketch of the Scientific Work

OF

PROF. A. H. WORTHEN.

BY CHARLES A. WHITE.

Professor Worthen began the work which has made his name so widely known at a time when little had yet been done in geological science in our country, and he prosecuted it almost without interruption until his death in 1888. Like most of the earlier American naturalists, he began his scientific work as an amateur, and under difficulties that the younger naturalists of to-day, who have had the advantage of special training in scientific schools, and who have free communication with a multitude of scientific workers, cannot well understand.

His home being upon the Lower Carboniferous rocks of western Illinois, his opportunities were good for the study of their fossils and their stratigraphical relations; and it was doubtless this circumstance that gave bent to his future career. In the prosecution of his private studies he made many extensive journeys in the region traversed by the Upper Mississippi river, and brought together some of the finest collections of fossils from the formations there that have ever been obtained.

His first public work was performed sometime about the year 1853, as an assistant to Dr. J. G. Norwood, then State Geologist of Illinois, but little or no record of that work has been preserved. In 1855 he was appointed assistant to Prof. James Hall, then State Geologist of Iowa, and continued upon that work until its suspension in 1858. Besides contributing two important chapters to Professor Hall's report upon the geology of that State, he aided largely in constructing the geological section along the Mississippi river, from Lansing to St. Louis, which is published in that report.

In 1858 he was appointed State Geologist of Illinois by Gov. W. H. Bissell; and in connection with this office he performed the work which has been of so much honor to himself and credit to the State. From the time of his appointment, to the end of his life, he devoted himself to the State of Illinois almost exclusively, for he found there an ample field, not only for his own labors, but for those of all the assistants whose services he could obtain.

Upon entering upon the duties of his office he quickly comprehended the magnitude of the task that lay before him, and he began to gather about him men skilled in various branches of scientific work, among whose names are many that are familiar to the whole scientific world. The following is a list of those who have aided him in his work, and who have contributed their writings to his reports and other publications:

Bannister, Dr. H. M.	Lesquereux, Dr. Leo
Barris, Prof. W. H.	Meek, F. B.
Blaney, Dr. J. V. Z.	Miller, S. A.
Bradley, Prof. F. H.	Newberry, Prof. J. S.
Broadhead, Prof. G. C.	Prout, Dr. H. A.
Cope, Prof. E. D.	Scudder, S. H.
Cox, Prof. E. T.	Shaw, James
Englemann, Henry	Springer, Frank
Everett, Dr. Oliver	St. John, Prof. Orestes
Freeman, H. C.	Ulrich, E. O.
Green, H. A.	Wachsmuth, Charles

Whitney, Prof. J. D.

After his field work upon the State Survey had been accomplished, Professor Worthen was appointed Curator of the State Historical Library and Natural History Museum. In connection with the duties of this office he continued the preparation of the remaining results of his work on the survey for publication, which have appeared in Bulletin No. 1 of the Museum, and in the two last volumes of his great series.

The following is a list of the works which have been published by him, portions of which have appeared under his name alone, and other portions under the names of certain of his assistants respectively; but his name appears as joint author of the greater part of the work of his assistants.

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2. A. H. WORTHEN.

Geology of the Des Moines Valley. In Report Geol. Survey of Iowa, by JAMES HALL; Vol. 1, part I, pp. 147-182, 1858.

3. A. H. WORTHEN.

Geology of certain Counties, embracing the results of examinations in the counties of Lee, DesMoines, Henry, Van Buren, Jefferson, Washington and Wapello. In Report Geol. Survey of Iowa, by JAMES HALL; Vol. I, part I, pp. 183-258, 1858.

4. A. H. WORTHEN.

Remarks on the Discovery of a Terrestrial Flora in the Mountain Limestone of Illinois. Proc. Am. Assoc. Adv. Sci., 13th Meeting, Springfield, Mass., pp. 312-313, Cambridge, 1860.

5. A. H. WORTHEN.

Notice of a new species of Platycrinus and other fossils from the Mountain Limestone of Illinois and Iowa. In Trans. St. Louis Acad. Sci., Vol. I, pp. 569-571, 1860.

6. A. H. WORTHEN; F. B. MEEK and

Descriptions of new Carboniferous fossils from Illinois and other Western States. In Proc. Acad. Nat. Sci. Phila., Vol. IV, 2d ser., pp. 447-472, 1860.

7. A. H. WORTHEN; F. B. MEEK and

Descriptions of new species of Crinoidea and Echinoidea, from the Carboniferous rocks of Illinois and other Western States. In Proc. Acad. Nat. Sci. Phila.. Vol. IV, 2d ser., pp. 379-397, 1860.

8. A. H. WORTHEN; F. B. MEEK and
Remarks on the age of the Goniatite Limestone at Rockford, Indiana, and its relation to the "Black Slate" of the Western States, and to some of the succeeding rocks above the latter. In Am. Jour. Sci., Vol. XXXII, 2d ser., pp. 167-177, 1861.

9. A. H. WORTHEN; F. B. MEEK and
Descriptions of new Palæozoic fossils from Illinois and Iowa. In Proc. Acad. Nat. Sci. Phila., Vol. V, 2d ser., pp. 128-148, 1861.

10. A. H. WORTHEN.
Remarks on the age of the so-called "LeClaire Limestone" and "Onondaga Salt Group" of the Iowa Report. In Am. Jour. Sci., Vol. XXXIII, 2d ser., pp. 46-48, 1862.

11. A. H. WORTHEN; F. B. MEEK and
Note in relation to a genus of Crinoids from the Coal Measures of Illinois and Nebraska, proposed on page 174 of this volume of the Journal. In Am. Jour. Sci., Vol. XXXIX, 2d ser., p. 350, 1865.

12. A. H. WORTHEN; F. B. MEEK and.
Notice of some new types of organic remains, from the Coal measures of Illinois. In Proc. Acad. Nat. Sci., Vol. IX, 2d ser. pp. 41-53, 1865.

13. A. H. WORTHEN; F. B. MEEK and.
Remarks on the genus Taxocrinus (Phillips) McCoy, 1844; and its relations to Forbesiocrinus, de Koninck and Le Hon, 1854, with descriptions of new species. In Proc. Acad. Nat. Sci. Phila. Vol. IX, 2d ser. pp. 138-143, 1865.

14. A. H. WORTHEN; F. B. MEEK and.
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15. A. H. WORTHEN; F. B. MEEK and.
Contributions to the Palæontology of Illinois and other Western States. In Proc. Acad. Nat. Sci. Phila. Vol. IX, 2d ser. pp. 245-273, 1865.

16. A. H. Worthen; F. B. Meek and.
Contributions to the Palæontology of Illinois and other Western States. In Proc. Acad. Nat. Sci. Phila. Vol. X, 2d ser. pp. 251-275, 1866.

17. A. H. Worthen; F. B. Meek and.
Descriptions of Palæozoic fossils from the Silurian, Devonian and Carboniferous Rocks of Illinois and other Western States. In Proc. Chicago Acad. Sci. pp. 11-23, 1866.

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19. Geological Survey of Illinois, A. H. WORTHEN, Director, Vol. II, Palæontology, pp. i-xix and 1-470, plates I-L, Imp. 8vo. Chicago, 1866.

CONTENTS.

20. A. H. WORTHEN; F. B. MEEK and

Preliminary notice of a Scorpion, a Eurypterus? and other fossils from the Coal Measures of Illinois. In Am. Jour. Sci. Vol. XLV, 2d ser., pp. 19-28, 1868.

21. A. H. WORTHEN; F. B. MEEK and

Notes on some points in the structure and habits of the Palæozoic Crinoidea. In Proc. Acad. Nat. Sci. Phila., Vol. XX, 2d ser., pp. 323-334, 1868.

22. A. H. WORTHEN; F. B. MEEK and
Remarks on some types of Carboniferous Crinoidea, with descriptions of new genera and species of the same, and of one Echinoid. In Proc. Acad. Nat. Sci. Phila., Vol. XII, 2d ser., pp. 335-359, 1868.

23. Geological Survey of Illinois, A. H. WORTHEN, Director, Vol. III, Geology and Palæontology, pp. i-vii and 1-574, plates I-XX A.-H., and one map. Imp. 8vo. Chicago, 1868.

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Remarks on the Blastoidea, with descriptions of new species. In Proc. Acad. Nat. Sci. Phila., Vol. XIII, 2d ser., pp. 83-91, 1869.

27. A. H. WORTHEN; F. B. MEEK and
Note on the relations of Synocladia, King, 1849, to the proposed genus Septopora, Prout, 1858. In Proc. Acad. Nat. Sci. Phila., Vol. XIV, 2d ser., pp. 15-18, 1870.

28. A. H. WORTHEN; F. B. MEEK and
Descriptions of new species and genera of fossils from the Palæozoic rocks of the Western States. In Proc. Acad. Nat. Sci. Phila., Vol. XIV, 2d ser., pp. 22-56, 1870.

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PART I.

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    Remarks on the Relative Age of the Niagara and the so-called Lower Helderberg Groups. Proc. Am. Assoc. Adv. Sci., 19th Meeting, Troy, N. Y., pp. 172-175, Cambridge, 1871.

31. Geological Survey of Illinois, A. H. WORTHEN, Director, Vol. V, Geology and Palæontology, pp. i-iii and 1-619, Plates H, and I-XXXII, Imp. 8vo., Chicago, 1873.

CONTENTS.

32. Geological Survey of Illinois, A. H. WORTHEN, Director, Vol. VI, Geology and Palæontology, pp. i-iii and 1-532, plates I-XXXIII, Imp. 8vo., Chicago, 1875.

CONTENTS.

33. A. H. WORTHEN.

Descriptions of fifty-four new species of Crinoids from the Lower Carboniferous Limestones and Coal Measures of Illinois and Iowa. In Bulletin No. I, Illinois State Museum of Natural History, pp. 3-38, 1882.

34. A. H. WORTHEN.

Corrections and proposed new names for species previously described in Geological Survey of Illinois under names that were pre-occupied; and descriptions of two new species of fossil shells from the Coal Measures of Illinois and Kansas. In Bull. No. I, Illinois State Museum of Natural History, pp. 38-40.

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Economic Geology of Illinois. Reprinted from the original reports of the Geological Survey with additions and amendations. Published by authority of the Legislature of Illinois, Springfield, 1882. Vol. I, pp. 541, Vol. II, pp. 615, Vol. III, pp. 596.

36. Geological Survey of Illinois, A. H. WORTHEN, Director, Vol. VII, Geology and Palæontology, pp. i-iv and 1-373, plates I-XXXI, Imp. 8vo. Chicago, 1883.

CONTENTS.

CHAPTER I.

PART II.

37. A. H. WORTHEN.
Bulletin No. 2 of the Illinois State Museum of Natural History. Descriptions of two new species of Crustacea, fifty-one species of Mollusca, and three species of Crinoids, from the Carboniferous formation of Illinois and adjacent States, pp. 27, Imp. 8vo. Springfield, March, 1884.

38. Geological Survey of Illinois; A. H. WORTHEN, Director, Vol. VIII, Geology and Palæontology, pp. i-xi and 1–728 Plates I-LXXVIII. Posthumous publication, edited by JOSUA LINDAHL. With an appendix, pp. 1–151, and map. Imp. 8vo. Springfield, 1890.

CONTENTS.

SECTION V.

SECTION VI.

APPENDIX.

The foregoing list comprises all the publications of Professor Worthen that have come to the knowledge of the writer, and it is believed to be nearly or quite complete. It is proper to say that nearly or quite all the matter contained in the publications mentioned in that list, exclusive of the eight large volumes of Survey reports, is also contained in those volumes in a completed form. That is, those publications consist of material which was printed in advance of the reports, or of that which has been abstracted from those volumes after their publication.

The eight large volumes and accompanying maps therefore represent fairly the results of Professor Worthen's life work. It is impracticable to present an extended analysis of that work on this occasion, but the following brief summary will serve to give an indication of its magnitude.

This great work embraces the geology, both structural and economic, and the palæontology of Illinois. In the geological division was accomplished the mapping, upon one comprehensive sheet and various smaller ones, the nearly 56,000 square miles which are embraced within the boundaries of that State, in such a way as to show its geological structure and the area occupied by each formation. The geological structure is further shown by numerous measured sections, most of them showing local relations of the strata, but the principal one was constructed from exposures along the Mississippi river, which forms the whole western boundary of the State. This section shows the relation of the different formations, from the Potsdam Sandstone to the Coal Measures, inclusive, for a distance of more than 600 miles.

The immense economic resources of the State are also shown in these volumes. The characteristics and outlines of its 37,000 square miles of productive coal field are recorded. The lead region has been carefully explored and mapped, and the character of its mineral products determined. Besides this the character of the soils of the State is described; and its resources in stone and other building material are shown to be abundant and good.

The most conspicuous portion of this great work, however, is its palæontology. This portion is so extensive and elaborate that the volumes of the Illinois survey have long been indispensable to every palæontologist in every part of the world where the palæozoic formations are studied. The fossil forms described are all well illustrated. They have been collected from all the formations, from the Potsdam Sandstone to the Upper Coal Measures, inclusive; but those of the Lower Carboniferous and the Coal Measures are especially abundant. Some indication of the extent of this palæontological work is shown by the fact that it embraces the description and illustration of 297 species of vertebrates, 1073 species of invertebrates and 256 species of plants. Nearly 1,500 of these species were first made known to the scientific world through the publications enumerated in the foregoing list.

Such briefly are the character and extent of the labors of one who for nearly forty years devoted his best energies to their fulfillment.

GEOLOGICAL SURVEY OF ILLINOIS.

A. H. WORTHEN, DIRECTOR.

GENERAL INDEX

TO

VOLUMES I–VIII.

BY

DR. JOSUA LINDAHL.

1890.

A. GEOLOGY, with List of Illustrations.

B. PALÆONTOLOGY:

I. Synoptic Table.

II. Plants,

III. Animals,

Approximate Geological Map of Illinois.

GENERAL INDEX TO GEOLOGICAL SURVEY OF ILLINOIS.

VOLUMES I—VIII.

A. GEOLOGY.

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* The items of each county report are not arranged alphabetically in this index, but generally in the following order: Physical features, Sections of Strata. Stratigraphical Geology (in chronological order), Economical Geology, Indian antiquities.

LIST OF ILLUSTRATIONS.

B. PALÆONTOLOGY.

I. SYNOPTIC

	LOWER SILURIAN.			UPPER SILURIAN.		DEVONIAN.	
	Canadian Group.	Trenton (and Galena) Group.	Cincinnati Group.	Niagara Group.	Lower Helderberg Group.	Corniferous and Oriskany Groups.	Hamilton Group.
Plantæ.	(I,152)						
Rhizopoda.				III,345; VI,500.			
Spongiæ.		III, 301—307; VI,491,492; VIII,258...282.		III, 344—346: VI,499.			III,418; VIII,251.
Anthozoa.		III,304.			III,368—370	III,407—410	III,420.
Palæocrinoidea.			III,324—334 VI,492,493.	III,347,349; VI,499; VIII,96,208	III,370.		III,421—423 VI,510; VIII,90.
Cystidea.		III,291—294	III,329—333				
Agelacrinoidea.							
Blastoidea.							VII,346-364
Stellerida.							
Echinida.							
Bryozoa.		VIII,405...523.	VIII,405...647.	VIII, 463, 499.	VIII,556...650.	VIII, 487, 490.	II,423; VIII,407...649.

TABLE.

Subcarboniferous.					Carboniferous.	
Kinderhook Group.	Burlington Group.	Keokuk Group.	St. Louis Group.	Chester Group.	Coal Measures.	
				II, 453, 458, 466; IV, 451, 474, 475.	II, 425—470; IV, 375—508.	Planta.
					V, 560.	Rhizopoda.
II, 146.	VIII, 249.	II, 233, 234; VIII, 250.	II, 262.		VIII, 245—247.	Spongiæ.
VIII, 75, 79.		VIII, 72...78	VIII, 74...80	VIII, 73, 78, 82.	V, 560; VI, 525.	Anthozoa.
II, 151; VII, 285, 310 VIII, 88, 96, 165—200.	II, 169—207; III, 463—495 V, 323—461; VII, 301, 304	II, 234—245; III, 511—521 V, 483—506; VI, 514—519 VII, 269.... 314; VIII, 84... 101.	II, 263—274; V, 530—537; VI, 518—520 VII, 286... 307; VIII, 89, 99.	II, 288—294; V, 546—559; VII, 290... 342; VIII, 87... 91.	II, 310—320; V, 561—566; VI, 526—528; VII, 317, 343—345.	Palæocrinoidea.
						Cystidea.
		V, 513—516		VII, 335-337		Agelacrinoidea.
VIII, 203, 205.	III, 496—499 V, 461—473	V, 506—509	II, 274—276; V, 537—539; VI, 521.			Blastoidea.
	III, 499; V, 474—476.	III, 526—528 V, 509, 510	II, 277—280	VII, 327-331		Stellerida.
	II, 230; V, 473—482.	II, 247—251; III, 522—525 V, 510—513	VII, 338.	II, 294—296; VII, 331-334	VII, 337, 338.	Echinida.
VIII, 428, 619.	III, 501—504 VIII, 429... 652.	II, 412—422 VIII, 429... 677.	II, 413, 415, 421; VIII, 434... 665.	II, 421; VIII, 432... 669.	VIII, 446...661.	Bryozoa.

SYNOPTIC

	Lower Silurian.			Upper Silurian.		Devonian.	
	Canadian Group.	Trenton (and Galena) Group.	Cincinnati Group.	Niagara Group.	Lower Helderberg Group.	Corniferous and Oriskany Groups.	Hamilton Group.
Brachiopoda.		III, 305.	III, 335—337	III, 349—354 VI, 502.	III, 371—384	III, 393-404, 410—416.	III, 423—437
Pteropoda.			III, 341—343				
Gasteropoda.	(I, 152)	III, 312—318	III, 340.	III, 359—363	III, 384—390	III, 404—406	III, 441—443
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Lamellibranchiata.		III, 294-298, 306—312; VI, 494—496	III, 337—340 VI, 495.	III, 354—359		VI, 511.	III, 437—441
Annelida.	(III, 280)						
Trilobita.		III, 299, 300, 320—323.	VI, 497, 498.	III, 363—367 VI, 508—510	III, 390—392	III, 416—418	III, 447—449
Other Crustacea.							
Arachnida, Myriopoda and Insecta.							
Pisces.							II, 106; VI, 251—253
Batrachia.							

Fossils of the *Cretaceous* (Tertiary?) system are referred to in I, 44-46; VIII, 3-5; and of the *Quaternary* system in VIII, 8, 9, 15.

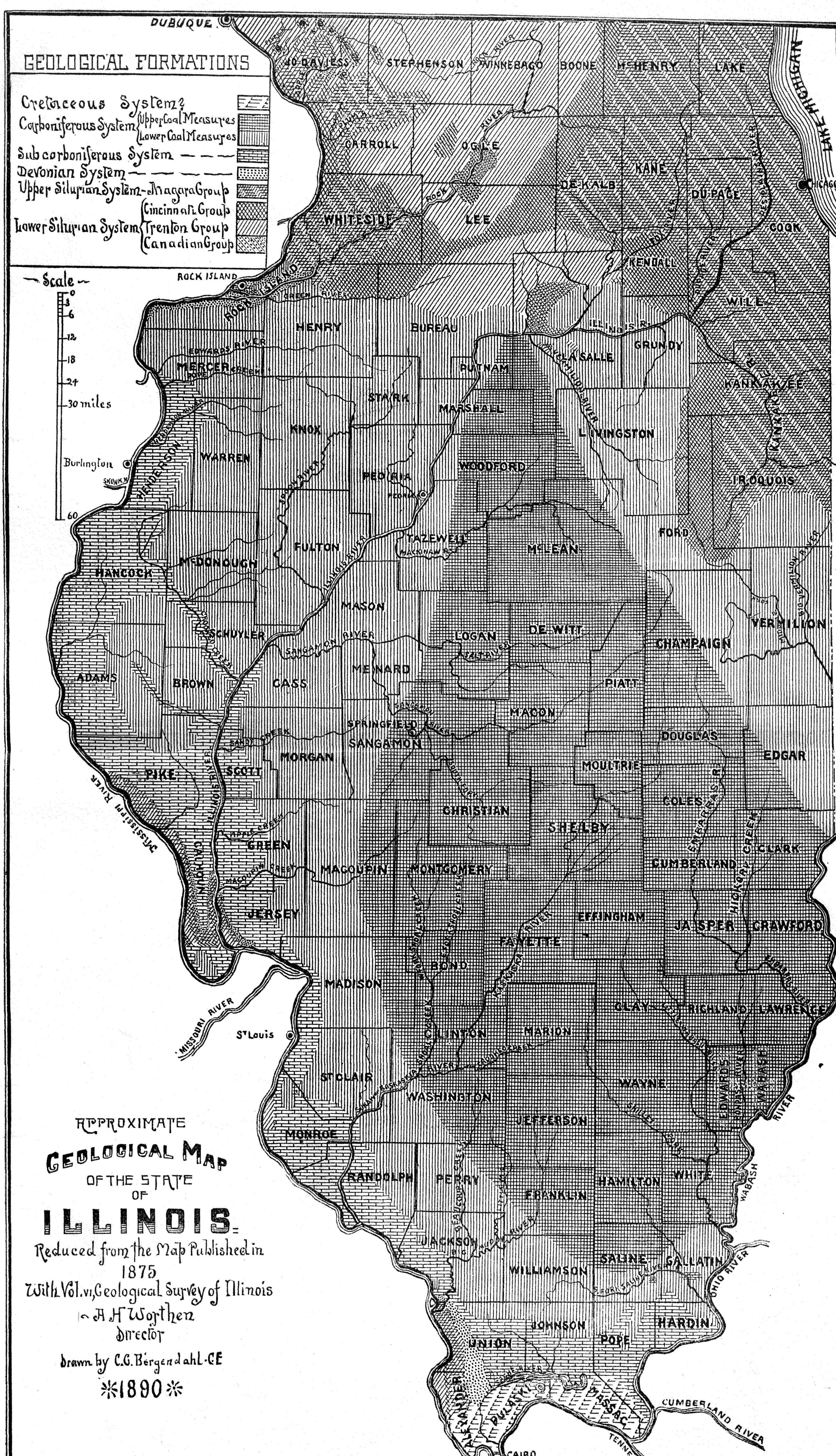
TABLE—*Continued.*

Subcarboniferous.					Carboniferous.	
Kinderhook Group.	Burlington Group.	Keokuk Group.	St. Louis Group.	Chester Group.	Coal Measures.	
II,153—155; III,450—452	III,505; VIII,103.	II,251—254; III, 528—532; VI,521—524 VII,321,322 VIII,102.	II,280; VIII, 103, 105.	II, 297—299	II,320—324; V,566—573; VII,318; VIII,104,106.	Brachiopoda.
		V, 520—522	V,541.	VII,325; VIII,134.		Pteropoda.
II, 159,160; III,457,458.	III,506—510 VII,325; VIII,137.	II,260; V, 516—520; VIII, 138, 141—144	II,284—286, VIII, 143, 144.	II,302—304; VII,325; VIII, 141—145.	II,351—385; V,589—608; VIII,135—147.	Gasteropoda.
II, 162—165 III,458—460	VII,325	V,522—525	II,286; V,543—545; VIII,150.	II,304—309; VII, 323—325; VIII,149.	II,386—393; V,608—612; VI,531,532; VII,324; VIII,148,150.	Cephalopoda.
II,157; III,453—456 VIII, 115, 118,	II,231; VIII,130.	II,256—258; III,532—539 VI,524,525; VIII, 108—133.	II,281—284; V, 539—541; VII,326; VIII,109...132.	II,300—302; VII,326; VIII, 107—130.	II,326—350; V,573—589; VI,529—531; VII,319; VIII,110...129,	Lamellibranchiata.
					II,462.	Annelida.
III,460.		V, 525—529			V,612—618.	Trilobita.
			VIII, 154	VIII, 153	II,393—408; III,540—555; V,618,619.	Other Crustacea.
					III409—411; II,,556—568.	Arachnida, Myriopoda and Insecta.
II,i; VI,483—488 VII,261.	II,ii; IV, 355...374; VI,483—488 VII, 261—264.	II,ii,iii; IV, 356...368. VI, 483—488; VII, 261—264.	II,iii; IV, 354...369; VI,483—488 VII, 261—264.	II,iv; IV,368; VI,483—488 VII, 261—264.	II,v; IV,347...372; VI,483—488. VII,261—264.	Pisces.
					II,135—141.	Batrachia.

II. Fossil Plants.

Numbers in **full face** refer to pages where diagnoses are given; an asterisk (*) after the number indicates that an illustration of the species is given on the plates; a cross (†) after the number indicates that an illustration of the species is given in the text.

III. Fossil Animals.


GEOLOGICAL FORMATIONS
Cretaceous System?
Carboniferous System
Upper Coal Measures
Lower Coal Measures
Sub carboniferous System
Devonian System
Upper Silurian System — Niagara Group
Lower Silurian System
Cincinnati Group
Trenton Group
Canadian Group
Scale
30 miles
60
APPROXIMATE
GEOLOGICAL MAP
OF THE STATE
OF
ILLINOIS.
Reduced from the Map Published in
1875
With Vol. vi, Geological Survey of Illinois
A. H. Worthen
Director
Drawn by C. G. Bergendahl. CE
1890
DUBUQUE
JO DAVIESS
STEPHENSON
WINNEBAGO
BOONE
McHENRY
LAKE
LAKE MICHIGAN
CARROLL
OGLE
DE KALB
KANE
DU PAGE
CHICAGO
COOK
WHITESIDE
LEE
KENDALL
WILL
ROCK ISLAND
HENRY
BUREAU
GRUNDY
LA SALLE
PUTNAM
MERCER
STARK
MARSHALL
KANKAKEE
KNOX
LIVINGSTON
WARREN
HENDERSON
Burlington
PEORIA
WOODFORD
IROQUOIS
FORD
FULTON
TAZEWELL
McLEAN
McDONOUGH
HANCOCK
MASON
VERMILION
SCHUYLER
LOGAN
DE WITT
CHAMPAIGN
ADAMS
BROWN
CASS
MENARD
PIATT
MACON
SPRINGFIELD
SANGAMON
DOUGLAS
EDGAR
PIKE
SCOTT
MORGAN
MOULTRIE
COLES
CHRISTIAN
SHELBY
CLARK
GREEN
MACOUPIN
MONTGOMERY
CUMBERLAND
JERSEY
EFFINGHAM
JASPER
CRAWFORD
FAYETTE
BOND
MADISON
CLAY
RICHLAND
LAWRENCE
MISSOURI RIVER
St Louis
CLINTON
MARION
ST CLAIR
WASHINGTON
WAYNE
EDWARDS
WABASH
MONROE
JEFFERSON
RANDOLPH
PERRY
HAMILTON
WHITE
FRANKLIN
JACKSON
WILLIAMSON
SALINE
GALLATIN
OHIO RIVER
UNION
JOHNSON
POPE
HARDIN
ALEXANDER
PULASKI
MASSAC
CAIRO
CUMBERLAND RIVER
TENNESSEE R.
MISSISSIPPI RIVER
ILLINOIS RIVER