THE STRATIGRAPHY AND PALEONTOLOGY OF THE CINCINNATI SERIES OF INDIANA.

BY

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PART I: GENERAL INTRODUCTION AND STRATIGRAPHY.

The present report is the result of studies begun in the summer of 1900, and continued with some more or less prolonged interruptions up to the present time. Parts of the field seasons of 1900, 1901, 1906 and 1907, have been spent, in conjunction with students of the Department of Geology of the Indiana University, in the study of the sections herein described and in the collection of fossils. The sections have been selected with a view to the elucidation of the differences between the northern and southern portions of the area studied, and with reference to their accessibility and to continuity of exposure. The last has presented more difficulties, perhaps, than any other requirement of the work; since continuous exposure is rare enough in any formation and especially so in a formation which, as is the case with the Cincinnati series, contains much intercalated shale. Nevertheless, as will be seen by a reference to the sections themselves, this requirement has been met with a reasonable degree of success. Wherever possible exposures in the beds of creeks have been sought, since cliff sections or those in railroad cuttings are usually so submerged in talus that it is a very difficult matter to be sure that every specimen is exactly located as to horizon—a requirement that has at all times been adhered to as paramount.

The exigencies of the last requirement will explain to some degree the failure of many rare forms to appear in the lists, and the seeming meagreness of some of the lists of species in parts of the series that in the Cincinnati region, as may be seen from the excellent paper of Nickles, have afforded a very large number. It must be remembered, however, that the forms listed in that paper and the various catalogues that have been published of the fossils of the Cincinnati group, represent the gleanings of the past half century from very numerous exposures, and by many collectors; and also that very many of them are of the rarest sort. No attempt has been made to secure rare forms. The main purpose of the work has been to fix so far as possible the range of the commoner forms, which after all are the only ones that can be of much use in stratigraphic work. I have also tried to collect in such a way as to eliminate the personal equation, in order to arrive at a more satisfactory estimate of the relative abundance of the forms. To this end I have avoided the practice of collecting large numbers of some particular species just because it happens to be abundant or especially well preserved. I have attempted in any given exposure to obtain in their proper numerical ratio every species to be found in the given exposure. One matter must be taken into consideration in the comparison of the faunules of different zones in a given section, namely, that some zones are of necessity much better exposed for collecting than others, and on that account may have a larger showing in the lists, although not really possessing a larger faunule. This is one of the sources of error that only years of careful zonal collecting can remedy; and the present report, it is hoped, will stimulate much further work of this sort in the Ordovician rocks of Indiana..

In many instances the section has been arbitrarily divided into divisions of a few feet in thickness, in order that the analysis of the section, foot by foot, might bring out the true relation of the faunules. This has been carried out in most detail in the upper part of the Tanner's creek section, where a five-foot division (one lap of the Locke level) was used, and in several cases even the top and bottom portions of the division were kept separate. That this is not an unnecessary refinement is shown by the fact that the faunule may change radically within a few inches of rock, in some cases, while in others the change comes on gradually, and is distributed through many feet of rocks.

Not only has the exact level of the fossil been determined with the utmost care, but the location of the section and any given division of the section on the map has been determined with equal care. In order to accomplish this a good large scale map was used and each division of the section accurately located and its number marked on the map. This gives the element of distribution equal precision with that of range. The system of nomenclature used for the numbering of sections and their divisions is a modification of that used by Prof. H. S. Williams, to whom all stratigraphers are deeply indebted in so many ways. According to this system, used at the Indiana University, a number is given to each State, Indiana being No. 1. Each town or locality at which collections are made then receives another number, which is written after the number indicating the State, with the decimal point between. Thus, Tanner's creek, Indiana, is 1.34. Any given section at the locality receives a letter. Thus the upper end of Tanner's creek is section A, and would be written 1.34A. The division of the section is then written after the letter as a number. Thus, 1.34A15, which would then mean Tanner's creek, Indiana, section A, number 15. All this is very compact and may be entered upon each specimen when the latter is finally installed in the museum. These numbers are also very convenient to enter upon the map or in the note-book, and upon library cards, on slides containing thin sections of the fossil, etc. They convey a large amount of information in a very small space.

In the description of the species I have, with very few exceptions, given the original description of the species in the exact words of the author. This has been done because of the great number and variety of the publications in which these descriptions have appeared, and because of the increasingly great difficulty of obtaining many of them. This report is not intended merely for the specialist, but for the amateur and local collector as well. It is intended to show what is known of the Ordovician fossils of Indiana and to serve as a stimulus to further work in the same direction. In every case where the original description of a fossil is inadequate, I have supplemented it with a further description, drawn wherever possible from my own material. I have not, however, used my own material when a better description could be gathered from the literature, and in many of the rarer forms this has been the case. I have made no attempt to revise the species and genera described in this report, except in the case of a few of the Bryozoa and Brachiopoda. Undoubtedly a great deal of revision is needed in some of the groups; but I believe that such revision should await the collection of very much additional material.

The illustrating of this report has given me the greatest trouble. I have not possessed the means to hire the illustrations made, and I have not had the time to draw them myself with pen and ink as I should have liked to have done. The only thing left to me was the method of retouched photographs, reproduced by the half tone process. This has the advantage of faithfulness to the original, but suffers perhaps more than any other method from the carelessness of the engraver and the printer. The making of the illustrations has been an immense labor, even with the potent aid of photography.

By far the most abundant fossils of the Cincinnati group are the Bryozoa. In the majority of exposures one-half or more of all the species collected will be bryozoa, practically all belonging to the one order of Trepostomata (Monticuliporidae of older authors).* The extent to which these fossils have been neglected heretofore by Indiana collectors is shown by the fact that while about 150 species of Bryozoa are listed in the present report, not more than thirty are listed in Kindle's catalog of Indiana fossils (published in 1897). Undoubtedly it has been commonly known to the various Cincinnati collectors who have made a special study of the Bryozoa, that these forms occur in Indiana; but hitherto there has been no published record of the fact. Probably the reason for the neglect of these forms is to be found in the great difficulties in the way of their study, and in the tendency of those who depend on surface characters to throw them into a few well known species. While it is possible for a specialist in the group to make a fairly sure identification on the basis of external characters, even he will make mistakes occasionally, unless assisted by thin sections, showing the internal characters. The preparation of such sections involves a great amount of labor, but it should always be considered as a necessary part of the study of these forms. In the study of the material for the present report, I have prepared over 1,500 slides aggregating over 3,000 thin sections of Bryozoa. The method of preparation of such sections is now pretty well known, and I shall briefly describe it when we come to the consideration of that group of fossils. I only wish at the present time to emphasize the *necessity* of their preparation.

Not only are the Bryozoa very abundant, but they are often most excellent zone markers. Mr. Nickles even goes so far as to subdivide the Eden and Lorraine formations into a series of bryozoan zones. Theoretically this procedure has entire justification; but as a matter of practice in the field in the hands of any but an experienced student of the Bryozoa, it is fraught with grave difficulties, because of the uncertainty of identification of most of these forms by such study as can be given them in the field; and every stratigrapher knows the value of easily recognizable forms in field work. I have therefore, whenever possible, made use of the Brachiopoda as zone markers, and have found that some even of the wide-ranging species may be thus used if due attention is paid to their zonal variations and relative abundance.

*The controversy as to whether these fossils are to be referred to the Bryozoa or to the corals may, I think, be considered as settled in favor of the former.

For such purposes the Brachiopoda are almost ideal. They are usually well preserved and abundant, and are reasonably susceptible to changing conditions of environment, though not as quick in their response to such changes as some other groups. If, however, we learn to appreciate small variations we shall be in a position to make a more extensive, and I believe, a safer use of these forms than has been thought possible by some paleontologists. I have already shown this to be the case in *Platystrophia,* and I shall try to make it as clear in some other genera. Even so long-lived and ubiquitous a form as *Rafinesquina alternata* presents zonal variations that can be utilized for our purposes. Not only can the small variations of species that mark the transition from zone to zone be utilized by the stratigrapher, but the relative abundance of a given form frequently serves the purpose of marking a zone with equal certainty, and is much easier to use. For example, the sudden appearance of *Plectambonites sericeus* in immense numbers in a certain layer of the Richmond formation has furnished a ready and reliable means of tracing the horizon of its occurrence all over the Indiana region. Now *Plectambonites sericeus* is a very long-lived and widely-distributed form, and presents exceedingly little variation throughout its range; nevertheless, for the reason stated, it proves to be a most excellent zone marker. On the other hand, some of the Brachiopoda have a very limited range in the Cincinnati rocks. This is true, for example, of *Dinorthis retrorsa* and *Zygospira headi,* which make their appearance in some abundance at one particular level and are not met with elsewhere. *Hebertella insculpta* is a form of similarly though not so severely restricted range. *Dalmanella meeki* and *Rhynchotrema dentata* mark considerably thicker zones, but nevertheless zones of very homogeneous faunal composition.

Doubtless the Pelecypoda would make very delicate zone markers, but unfortunately they are scarcely ever abundant, and are usually very poorly preserved. Much the same is true also of the Gasteropoda, while the Cephalopoda are in a still worse plight, being usually in such a state of preservation as to make their identification largely a matter of guesswork.

Of other classes, the Crinoidea are almost never represented by anything more than the segments of the stems and an occasional plate of the calyx. Inchoate calices are extremely rare. Corals have a very feeble representation throughout the greater part of the Cincinnati group, although in the Richmond formation a few species are abundant, and two, namely *Columnaria alveolata* and

Tetradium minus are excellent zone markers. The Trilobites, excepting the three species *Calymene callicephala, Isotelus maximus* and *I. gigas,* are rare and poorly preserved, and the species mentioned are such widely ranging forms and present so little variation as to be of little use. The Ostracoda in the hands of a skillful student of the class would undobtedly prove excellent zone markers, since they are nearly always present in numbers and do not range very widely. Their study is, however, a matter of great difficulty and some uncertainty, and they present the same difficulties to the field geologist as the Bryozoa. Such forms as worms and problematica need not be considered in the present connection.

Passing by the question of the usefulness of some particular species as a zone marker, it is important to consider the value of the general or total expression of the faunule.

It is perfectly possible for a given species or for several associated species to recur in several more or less widely separated zones, but it is more than unlikely that an association of many species will ever recur in precisely the same association, that is, with the same species present in the same relative numbers. The *expression* of the faunule is therefore reliable within a given rather limited area; for the faunule may change laterally as well as vertically. This last fact calls for great care in the endeavor to trace zones over considerable areas; and makes it safer in many instances to correlate by means of a particular species or a particular few species than by the faunal expression.

In what has been said so far no mention is made of the use of lithology for purposes of the correlation of more or less widely separated exposures. There is not much to say. The Cincinnati series presents a succession of shales and limestones in which there is not much that is distinctive for the purposes of correlation. Certain major details may indeed be made out, such for example, as that the Eden beds consist mainly of shale with an occasional thin layer of limestone, while the Lorraine consists largely of limestone with intercalated shale. The lower Richmond (Waynesville) formation is more predominantly shale than the middle Richmond. On the other hand the Saluda consists at Richmond almost entirely of limestone, while at Madison it consists of massive calcareous sandstones. To attempt to trace the smaller subdivisions of the Cincinnati series by means of lithology would be futile. On the whole I have considered it best to practically disregard lithology, so far as the correlation of distant exposures is concerned. Within small areas it will be found useful, if used with discretion. In one instance the lithological characters of a stratum have served in tracing it over the greater part of the region. This is the case of the shale bed at the base of the Saluda formation. Even here, however, the evidence of fossils has constantly been appealed to—in this case the presence of the Corals, *Columnaria alveolata* and *Tetradium minus*. Farther east than the Indiana region, this shale bed fails, and the faunal evidence weakens to such an extent that the discrimination of the zone in question has remained up to the present time a matter of doubt.

The area of the outcrop of the Ordovician rocks in Indiana comprises all of the counties of Switzerland, Ohio, and Dearborn, except a very small area in the northwestern corner of Switzerland; and the greater part of the Counties of Wayne, Franklin, Union, and Fayette, together with the eastern half of Ripley and the eastern edge of Jefferson. Besides this area, which constitutes one continuous tract extending from Richmond on the north to Madison on the south, and having its western boundary nearly on a straight line extending from Hagerstown, in Wayne County, to Madison, in Jefferson County; there are several isolated, and very much smaller areas, in the counties of Decatur, Ripley, Jennings and Clark.

The best known localities for the collection of fossils within this area are Richmond, Versailles, Madison and Weisburg. Besides these may be mentioned Lawrenceburg, Vevay, Moores Hill, Osgood, Laurel, Brookville, Liberty and especially the new cuts along the Big Four R. R. between Weisburg and Guilford, where there is now a continuously exposed section from the middle Utica to near the top of the Ordovician. This last series of exposures has been opened up since my collections were made from the Tanner's creek section, and it is a matter of regret that I have not had the time since to work up a new collection of material from this section. I hope at some future time to publish a revised section of Tanner's creek, based on collections from these railroad cuts. I was unfortunately in the East during the time that these cuts were being excavated and thus missed the rare opportunity to collect from the dumps as the material was carried out of the cuts. It is still possible, however, to make very full and detailed zonal collections from this locality.

I cannot conclude this introductory sketch without gratefully acknowledging the assistance that I have from time to time received from my students and others in the preparation of this report. During the first summer of my field work I was accompanied by

four students, W. P. Jenkins, A. V. Redmond, John Crowley, and L. M. Moore; and during the second summer by A. V. Mauck, James Frazer, Frank Buser, and W. F. Oesterle. Most of the collecting was done in these two seasons and was very greatly aided by these gentlemen. During the summer of 1906, I was assisted in the field by G. E. Burton and Albert W. Thompson, and during the summer of 1907, by W. M. Tucker. To these men I am under especial obligations. Mr. Tucker has rendered me assistance in the preparation of the maps that accompany this report, without which I could scarcely have brought the report to a conclusion in the time at my disposal. Miss Maude Siebenthal has retouched most of the photographs that illustrate the report, and has in other ways been of great service to me. The following libraries have loaned me literature: State Library of New York, Congressional Library, Library of Chicago University, Crerar Library of Chicago, and the State Library of Indiana. In addition, Professor Charles Schuchert of Yale University loaned me books and pamphlets from his own library and the library of Yale University. Dr. Stuart Weller of Chicago University very kindly sent me several of the types in the James collection of Cincinnati fossils. To my colleague, Dr. Beede, I am also under obligations for much advice and assistance in the work. Finally, I wish to acknowledge most gratefully the kindness of Mr. W. S. Blatchley, the State Geologist, in making possible the publication and proper illustration of this report, and for many courtesies during its progress through the press.

HISTORICAL SKETCH.

The history of the investigation of the rocks of the Cincinnati group during the past three-quarters of a century has been summarized by Nickles in his paper on the Geology of Cincinnati[1] and the history of the various names of the larger subdivisions of these rocks is also given by Prosser in Bulletin No. 7 of the Ohio Geological Survey.[2] It will not be necessary, therefore, to go into the details of this part of the discussion. I shall give very briefly the history of the names, as it is outlined by Nickles, following this with a chart showing these various names and their equivalence.

This series of rocks was first known as the Blue Limestones of the West, or simply the Blue Limestone. D'Orbigny, for example, in his Prodrome lists a number of fossils from the "Blue Lime" of

[1]Jour. Cin. Soc. Nat. Hist., vol. XX, No. 2, 1902, pp. 52–60.

[2]Revised Nomenclature of the Ohio Geological formations. Geological Survey of Ohio, Fourth series, Bull. No. 7, pp. 29–36.

Ohio. These so-called Blue Limestones were at first supposed to be equivalent to the Trenton limestone of New York[3], an error that was not corrected for many years. With the extension of the careful investigations of Hall and others to the western localities, this mistake was gradually rectified. Hall in 1842[4] correlated the limestones exposed at low water in the banks of the Ohio River at Newport, Ky., with the Trenton, a correlation that subsequent studies have shown to be correct. This correlation lead to considering the overlying series of rocks as the equivalent of the Hudson River shales of New York. This latter correlation was definitely made by Hall in 1843[5]. In 1862, however, he abandoned the term, considering these rocks as younger than the New York series of shales known as the Hudson River group; but in 1877[6] he returned to the use of the term for the Ohio formations. In 1865 Meek and Worthen proposed the term "Cincinnati group," to take the place of the at that time discarded term Hudson River group.[7] This term was adopted by the second Geological Survey of Ohio. The term did not, however, find general acceptance, and in 1879 a committee of the Cincinnati Society of Natural History, with Mr. S. A. Miller as chairman, was appointed to consider the question of the names of this series of rocks. This committee reported in favor of the term Hudson River group. Their report will be found published in the Journal of the Society[8]. From this report Mr. U. P. James dissented[9]. The term Cincinnati group still continued to be used by some of the Cincinnati geologists. In 1888 Edward Orton, Sr., State Geologist of Ohio, proposed, on the grounds of the revelations of well records, to discontinue the use of the term Cincinnati group.[10] Walcott also in 1890 favored the use of the term Hudson River group for these rocks.[11] Finally Dr. Ruedemann in 1900[12] showed that the series of shales in the Hudson valley represent beds ranging in age from the basal Trenton upward; and the name Hudson River Group was quietly dropped from geological nomenclature. By default of this older name, therefore, the very appropriate name of Cincinnati group or Cincinnati series became established.

[3]Vanuxem, Amer. Jour. Sci., vol. XVI, 1829, p. 256.
[4]Hall, Amer. Jour. Sci., vol. XLII, 1842, p. 61.
[5]Hall, Trans. Amer. Assoc. Geol and Nat., 1843, pp. 267–293.
[6]Hall, Proc. Amer. Assoc. Adv. Sci., 1877, vol. XXVI, pp. 259–265.
[7]Meek and Worthen, Proc. Acad. Nat. Sci., Philadelphia, 1865, p. 55.
[8]Jour. Cin. Soc. Nat. Hist., I, 1879, pp. 193–4.
[9]The Paleontologist, No. 4, 1879, pp. 27–28.
[10]Orton, Geol. Surv. Ohio, VI, 1888, p. 9.
[11]Bull. Geol. Soc. Amer., I, 1890, pp. 335–356.
[12]Ruedemann, Bull. New York State Museum, VIII, No. 42, 1900, pp. 564–568.

Subdivisions. In 1873 Dr. Edward Orton[4], of the Ohio Survey, subdivided the Cincinnati series into the Point Pleasant beds, exposed in the north bank of the Ohio River about twenty-five miles east of Cincinnati; the Cincinnati beds extending from the low water mark at Cincinnati to the tops of the hills at that city; and the Lebanon beds extending from the top of this division to the top of the Ordovician system. The Cincinnati beds proper, he subdivided into the River Quarry beds, 50 ft. thick, the Eden shales, 250 ft. thick, and the Hill Quarry beds, 150 ft. thick. The Point Pleasant beds belong to the Trenton series, and the balance to the Cincinnati series as now understood.

As far back as 1842, Hall had recognized the Utica shales in the Cincinnati section[5]. The rocks to which he applied the name were in part the same as the Eden shales of Orton. These rocks were also considered as equivalent to the Utica of New York by the committee of the Cincinnati Society of Natural History, alluded to above. In 1888 Mr. Ulrich correlated the beds No. XIb of his paper on the Correlation of the Lower Silurian Horizons with the black shales of the Findlay wells, which Orton correlated with the Utica shales. These beds XIb of Ulrich are the same, practically, as the Eden shales of Orton, and have, according to Ulrich, a thickness of 225 feet[6]. In volume VI of the Ohio Geological Survey, Orton is disposed to doubt the presence of the Utica in the Cincinnati section. In the Geology of Minnesota (1897) Winchell and Ulrich definitely correlate the Eden shales with the Utica shales of the eastern province[7].

In 1902 Nickles published a paper on the Geology of Cincinnati in which the term Utica is again used for these shales, and they are subdivided into three divisions, the lower, middle and upper, characterized by Bryozoa[8]. These bryozoan zones are in ascending order the *Aspidopora newberryi* beds, 80 ft. thick; the *Batostoma jamesi* beds, 120 ft. thick; and the *Dekayella ulrichi* beds, 60 ft. thick. This same subdivision of the Utica into lower, middle and upper is repeated by Nickles in Bulletin No. 5 of the Kentucky Géological Survey (1905). In this publication, however, he uses the term Eden shale in preference to Utica, and says in regard to this usage, "as the sediments [of the New York and Ohio valley

[4]Orton, Geol. Surv. Ohio, vol. I, 1873, pp. 365–449.
[5]Amer. Jour Sci. XLII, 1842, p. 61.
[6]Ulrich, Amer. Geologist, I, 1888, pp. 183–190, and p. 312.
[7]Winchell and Ulrich, Geol. and Nat. Hist. Surv. Minn., vol. III, pt. II, pp. ci–cii. and chart, p. lxxxix.
[8]Nickles, Jour. Cin. Soc. Nat. Hist., XX, No. 2, 1902, pp. 66–74.

regions] were deposited in different basins and under very different conditions, and as the faunas have scarcely anything in common, it seems better that they should bear different names; hence Orton's name Eden is revived for the formation developed in the Ohio valley." This proposed revival of the name Eden is, however, due to Foerste, who, in August, 1905, published the following opinion in Science: "The name *Eden,* well defined by Orton in the first volume of the 'Geology of Ohio' published in 1873, is revived for the strata which in the 'Geology of Cincinnati' [Nickles] are identified as Utica."[9]

Finally, in a paper on the James types of Lower Silurian Bryozoa, by Mr. Bassler (1906), is given a classification of the Cincinnati series[1], in which the term Eden is used for the greater part of these shales, with the older term Utica standing for the lower 5 ft., immediately overlying the Point Pleasant beds. To this lower 5 ft. the name Fulton is applied. In this classification the three subdivisions of the Eden shales receive the names Economy, Southgate and McMicken, in the ascending order.

To the limestone beds overlying the Eden shales, Orton, as we have seen, gave the name Hill Quarry beds, with a thickness of about 150 ft. The top of this division was marked by the "lynx beds," seen on the highest hills in the city of Cincinnati. In 1842, Emmons had applied the name Lorraine to the series of arenaceous shales exposed about Lorraine in Jefferson County, New York, and overlying the Utica shales[2]. In the chapter on the correlation of the rocks of the Cincinnati group, in their report on the Paleontology of Minnesota, Winchell and Ulrich proposed to apply this name (Lorraine) to the Hill Quarry beds of Orton[3]. Since that time the term has been more or less commonly employed. In his paper on the Geology of Cincinnati (*ante*), Nickles uses the term Lorraine group for these beds and subdivides the group into six divisions, as follows, in the ascending order: (1) Mt. Hope, or *Amplexopora septosa* beds, 50 ft.; (2) Fairmount, or *Dekayia aspera* beds, 80 ft.; (3) Bellevue, or *Monticulipora molesta* beds, 20 ft.; (4) Corryville, or *Chiloporella flabellata* beds, 60 ft.; (5) Mt. Auburn, or *Platystrophia lynx* beds, 20 ft.; (6) Warren, or *Homotrypa bassleri* beds, 80 ft. (*loc. cit.*, p. 75). This subdivision of the Lorraine was adopted by Bassler in 1903, in his paper on the Genus

[9]Foerste, Science, N. S., XXII, Aug. 4, 1905, p. 150.

[1]Bassler, Proc. U. S. National Museum, XXX, No. 1442, p. 8. This classification it is stated is in course of publication by Ulrich.

[2]Emmons, Nat. Hist. of New York, pt. II, geology of the Second District, 1842, p. 119.

[3]Winchell and Ulrich, Geol. and Nat. Hist. Surv. Minn., vol. III, pt. II, 1897, p. cii.

Homotrypa[4]. Here, also, Bassler accepts the names Utica and Lorraine. In 1905, however, Foerste[5] proposed to discard the name Lorraine and suggested the name Maysville from Maysville, Kentucky, for this division. This latter name was adopted by Nickles in his paper on the Upper Ordovician Rocks of Kentucky[6]. In Prosser's paper on the Revised nomenclature of the Ohio formations the name Lorraine is used[7]. It must be stated, however, that Prosser's manuscript was in the hands of the printer before this later suggestion of Foerste was published. Finally in the paper by Bassler on the James Types (*ante*), in the classification proposed by Ulrich, neither of the names Lorraine or Maysville are used, but the Utica, Eden and Lorraine (of other authors) are placed in a new division of larger rank, the Covington group, named from Covington, Kentucky (*loc. cit.*, pp. 8-10). In this classification the Mt. Hope and Fairmount divisions of Nickles are bracketed together as the Fairview division, and the Bellevue, Corryville, and Mt. Auburn divisions of Nickles are bracketed together as the McMillan division. These two together, therefore, constitute what has heretofore been known as the Lorraine division of the Cincinnati group. Thus out of this kaleidoscopic shifting about of names emerges a practically new set of names for this group of rocks.

For the upper division of the Cincinnati series Dr. Orton proposed the name Lebanon beds, with a thickness of nearly 300 ft. (*ante*). This division is now universally known as the Richmond formation, a name proposed by Winchell and Ulrich in the Geology of Minnesota[8]. The reason for the substitution of this name for the older name of Orton was the fact that the name Lebanon had previously been used by Safford for a member of the Trenton formation of Tennessee. In Nickles paper (*ante*), the Richmond is divided into the lower, middle and upper Richmond beds (*loc. cit.*, pp. 88-95). Judging from the fauna given, the upper Richmond of Nickles is the same as the Madison beds of Foerste (Saluda), which he named in 1896[9], and to which he has devoted a very considerable amount of study. In proposing this name, Foerste says: "In some regions these richly fossiliferous limestones and clay beds [of the upper part of the Cincinnati series] terminate quite abruptly 40 to 60 feet beneath the Clinton, and are overlaid by a very argil-

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[4] Bassler, Proceedings of the U. S. National Museum, XXVI, 1903, p. 567, foot note.

[5] Foerste, Science N. S., vol. XXII, 1905, pp. 149–152.

[6] Nickles, Bull. No. 5, Kentucky Geological Survey, 1905, p. 17, and table, p. 15

[7] Prosser, Geological Survey of Ohio, Fourth Series, Bull. No. 7, p. 3. But see remarks, p. 34.

[8] Winchell and Ulrich, Geol. Nat. Hist. Surv. Minn., vol. III, pt. II, p. ciii.

[9] Foerste, Indiana Dept. Geol. Nat. Resources, 21st annual Rept., 1896, p. 220.

laceous rock, or very impure limestone, which is described in the next section under the name of the Madison bed.'' In the discussion that follows Foerste says: ''In the vicinity of Madison, the top of the Lower Silurian is formed by a considerable thickness of argillaceous limestones, weathering on long exposure from light brown, more or less banded with darker brown, to even purplish tinted layers. . . . . The fossils in these argillaceous limestones are confined to a few layers, and by far the greater part of the layers are without fossil remains. Beneath the banded limestones occur eight feet of the *Favistella* bed, which, near Madison seems to form a well marked horizon.'' These banded limestones form many picturesque waterfalls in the vicinity of Madison and Hanover. The *Favistella stellata* is the *Columnaria alveolata* of the present report. The typical Madison bed, he further states, is commonly overlaid by limestone or shaly limestone containing fossils, among which are chiefly *Lophospira hammelli, Holopea hubbardi,* and *Leperditia caecigena. Labechia* and *Tetradium minus* also occur in these upper limestones. Speaking of the northern continuation of the Madison beds, Foerste says: ''North and northwest of the typical Madison bed, the top of the Lower Silurian rapidly changes in character. It is replaced by a series of blue, often rather dark blue, very fine grained limestones. . . . . Lithologically, this rock is similar to the dark blue, fine grained layer forming part of the *Murchisonia hammeli* layer in more southern areas. . . . . The fine grained, dark blue limestone, taking the place of the Madison beds, is interbedded with ordinary limestones, and with clays containing ordinary limestone fossils. Sections of this type begin to be exposed in northern Jefferson County, and are typically developed at Versailles, along the whole length of Big Graham Creek, and for some distance northwards. The correspondence of this section is very well seen in the exposure immediately north of Versailles, where 29 feet of this limestone, with its intercalated beds of clay and shale, are underlaid by 11 feet of unfossiliferous brownish and bluish shales, corresponding to the shales at the base of the Madison beds near Madison. Below the shales are 12 feet of limestone and shale, containing *Tetradium minor* at many levels, and *Favistella stellata* at the very base. This is the characteristic horizon for *Favistella* in southern Indiana. . . . . From the Baltimore & Ohio Southwestern Railroad northwards, all comparison with the Madison beds is lost. The upper strata consist commonly of thin or shaly limestones, interbedded with clays, both usually abundantly fossiliferous. No demarkation can be made between these upper strata and the lower horizons of the Lower Silurian, corresponding to the separation of the Madison from the richly fossiliferous shales in southern Jefferson and Clark counties. This means that the Madison beds are replaced northwestward by limestones. . . . .''

For a complete discussion of the literature of the Madison (Saluda) beds, the reader is referred to the paper by Dr. Foerste in the 24th annual report of the Indiana Geological Survey, pp. 45-68. In this place I merely desire to indicate the general conception of the Madison beds as set forth by the author of the name in his original paper.

Finding that the name Madison beds was preoccupied, Foerste, in 1902, proposed to substitute the name Saluda for these beds, from Saluda Creek, six miles south of Hanover, Indiana. This latter name is therefore used in the present report.

For the balance of the Richmond group—the lower and middle Richmond of Nickles—the name Waynesville[1], has been proposed for the lower division (for the most part); Liberty beds for the next higher division (Nickles, *loc. cit.*, pp. 207-208); and Whitewater division for the beds next above the Liberty (Nickles, *loc. cit.*, pp. 208-209). These beds are followed by the Saluda of Foerste. Foerste, in 1905, recognizing the fact that the Whitewater division of the Richmond section cannot be differentiated in the more southerly sections, proposed the name Versailles for the two divisions, Liberty and Whitewater[2]. For the Warren division, referred to the Lorraine by Nickles in his paper on the Geology of Cincinnati, but considered by Bassler, apparently following an unpublished view of Ulrich, as referable to the Richmond, rather than to the Lorraine, Foerste also proposed the name Arnheim (from the small town of that name near Georgetown, Ohio), because of the preoccupation of the name Warren. (Foerste, *loc. cit.*, p. 150.) Of these names, Liberty is from Liberty, the county seat of Union County, Indiana; and Waynesville, from the town of Waynesville, in Ohio; while Whitewater is from the Whitewater River at Richmond, Indiana, along which through the city of Richmond these beds are well exposed.

[1]Nickles, Amer. Geologist, XXXII, 1903, pp. 205–206.
[2]Foerste, Science, N. S. vol. XXII, 1905, p. 150.

TABULATION OF THE VARIOUS CLASSIFICATIONS OF THE CINCINNATI GROUP.

Early authors.	Orton, Ohio Survey, 1873.	Winchell and Ulrich, 1897.	Nickles, 1902.	Nickles and Foerste, 1905.	Ulrich, 1906. (Bassler.)	Present report.		
Blue Limestone of Ohio, Indiana, and Kentucky. Hudson River group of many. Cincinnati group of some authors.	Lebanon..............	Richmond..........	Richmond. Upper...........	Richmond. Saluda..........	Richmond group. Saluda..........	Richmond. Elkhorn.........	Platystrophia moritura zone.	
						Whitewater......	Rhynchotrema dentata zone.	
			Middle..........	Whitewater......	Whitewater......	Saluda...........	Tetradium minus zone	
				Liberty..........	Liberty..........	Liberty..........	Strophomena planumbona zone.	
			Lower..........	Waynesville......	Waynesville......	Waynesville......	Dalmanella meeki zone.	
			Lorraine. Warren.........	Maysville Arnheim........	Arnheim.........	Arnheim.........	Homotrypa bassleri zone of Nickles......	Rafinesquina alternata zone.
			Mt. Auburn......	Mt. Auburn......				
	Hill Quarry (in part)....	Lorraine............	Corryville........	Corryville........	Covington group. McMillan........	Maysville or Lorraine. Upper.........	Callopora rugosa zone.	
			Bellevue.........	Bellevue.........		Middle.........		
			Fairmount.......	Fairmount.......	Fairview........			
			Mt. Hope........	Mt. Hope		Lower.........	Platystrophia zone.	
					McMicken.......	Eden of Utica. McMicken (upper)	Dekayia ulrichi zone...	Dalmanella multisecta zone.
	Eden (in part)........	Utica..............	Utica. Upper...........	Eden. Upper...........	Southgate.......	Southgate (middle).......		
			Middle..........	Middle...........	Economy........			
			Lower...........	Lower...........	Fulton..........	Economy (lower).	Callopora oneali zone.	

EXPLANATION OF SECTIONS.

The detailed sections are given in the following pages without extensive comment, which is reserved till all the sections have been presented seriatim, in order that the whole subject of stratigraphy may be discussed in one place. While many sections have been measured besides those given in the succeeding pages, many of these have not yet been carefully collected from, or present nothing in addition to the points elucidated by the sections that have been included. Some of the sections, especially those near the top of the Richmond formation, along the line of contact of the Ordovician and Silurian, have not been carefully collected from as yet, and nevertheless are included because they bear upon the question of the horizon, thickness and distribution of the Saluda formation. The fauna of this formation is not extensive, but is nevertheless of very great interest, and I hope in a future paper to take it up in detail. The species listed from some of the sections of this formation were identified in the field (with the exception of the Bryozoa). In general this practice has not been followed, but the material has been removed to the laboratory and carefully studied there. All of the locality numbers will be found carefully marked in on the accompanying map.

It is necessary to explain that in a few cases the section numbers in the sections that follow do not correspond to those given in the body of the text where the localities are given after each species. This occurs in the case of section A at Richmond, Indiana (1.41A). The reason for this is that the section was measured at two different times, and that at the second measurement a somewhat different plan was adopted. All the collections are labeled, however, according to the numbers first adopted, and hence it became necessary to follow these original numbers in giving the localities after the description of each species. The numbers of section 1.41A, given on the chart, are those of the newer section. The equivalence of the old and new numbers will be found stated in the description of each section where such difference in numbering occurs. In the case of the *general* section along the Whitewater River at Richmond, numbers are used that do not correspond to those of the several sections (B, D, E), from which collections were made. The *general section* is a combination of these and bears its own numbers. In the case of the detailed section at Vevay (1.38A) the numbers are the original numbers, with the exception that I have added numbers 84 to 88 to include the portion of the section designated

Ba-h in my paper on the Vevay section. This includes most of the *Platystrophia* zone. Species given as coming from 1.38P were found loose in association with *Platystrophia lynx* at Vevay. The *general* section at Madison, Indiana, also has its own numbers, which do not correspond to those of sections A, D and E, of which it is made up.

No description of the Tanner's Creek section is given. The chart and profile are considered as quite sufficient. The thickness of the various divisions can be obtained from the chart, and the elevation of any collecting station above datum can be obtained from the profile.

Some slight explanation of the chart is perhaps needed. The species, as will be noted, are given in alphabetical order at the left. The occurrence of any given species is indicated by a straight line drawn on the chart, the weight of the line indicating the relative abundance of the species. In cases where the species is very abundant or dominant in the fauna the space is filled in solid black. At the top of the chart the localities are indicated, and by brackets are grouped into their respective sections. Along the top margin is also given a scale of feet, each space, reading across the chart, equalling five feet. The datum taken is the low water level of the Ohio River at Lawrenceburg, Indiana. In this section dip is disregarded. This does not introduce any considerable error, since the dip in the direction of the section is slight.[1] The highest exposure in the Tanner's Creek section is the Saluda division. For the remainder of the Richmond series that portion of the Richmond section coming above the Saluda, namely the Whitewater and Elkhorn divisions, is taken and added on to the Tanner's Creek section. The whole, therefore, becomes a general section of the Cincinnati series of Indiana.

LIST OF SECTIONS.

The starred sections are described in detail in this report.

5.9A*—Section opposite the mouth of the Miami river, in the Kentucky bank of the Ohio river, extending from the level of the river to the top of the hill. Eden and Lorraine.

[1]Allowance for the dip should be made, however, for section 5.9A, which is nearly six miles removed from the balance of the section. The base of section 1.34C is in reality probably not far from 60 ft., stratigraphically, above the top of section 5.9A. This makes the Eden shales about 220 ft. thick in this section, instead of 160 as the chart would seem to indicate. This discrepancy was realized too late to re-draw the chart. In the balance of the section the direction changes from nearly west to northwest, or from that of the main dip toward that of the strike; and the dip no longer introduces any serious error.

1.33A*—Section at the road metal quarry on the hill just west of Lawrenceburg, Indiana. Middle Lorraine.

1.34C*—Section along Tanner's creek from the level of the creek at Guilford to the top of the hill just east of Manchester Station, Indiana. Eden and Lorraine.

1.34B*—Section along Tanner's creek from Manchester Station to the first railroad bridge west of Harmon's station, Indiana. Upper Lorraine and Arnheim.

1.34A*—Section from the level of Tanner's creek at the second railroad bridge west of Harmon's station to the top of the first railroad cut north of Weisburg. Richmond.

1.35A—Section of the high hill in the south edge of Aurora, Indiana. Same beds as 1.33A3.

1.35B—Section along Whitaker's branch from Dillsboro station to Moore's Hill, Indiana. Shows all of Lorraine and Richmond to near base of Saluda.

1.36—Laughery creek, Indiana.

1.36B—Section of the north bluff of Laughery creek, one mile west of Milton, Indiana. Upper Utica.

1.36C—Section of the north bluff of Laughery creek, two miles southwest of Milton, Indiana. Upper Utica.

1.37A to H—All within a radial distance of four miles from Rising Sun, Indiana. Utica and Lorraine.

1.38A*—Section of the hill back of Vevay, Indiana, beginning at the head of Main Cross street. Utica and Lorraine.

1.38B*—Section along the old road (now closed) over the hill just back of Vevay. Same as 1.38A.

1.38C, D, E—Along Indian creek below Bennington, Indiana. Lorraine and Lower Richmond.

1.38F—On the east-and-west road one mile northwest of Bennington, Indiana. Liberty beds.

1.12A*—Section in the gulley just north of the north end of the south cut at Madison.

1.12B—Section along Clifty creek two miles west of Madison, Indiana. Top of Lorraine to top of Richmond.

1.12C—Section of Clifty Fall, Indiana. Saluda and Niagara.

1.12D*—Section of the North cut (Big cut) at Madison, Indiana. Liberty to Niagara.

1.12E*—Section of the south cut, Madison, Indiana. Arnheim and Waynesville.

1.12F*—Section in the north side of the highway a short distance below the Hanging Rock, Madison, Indiana. Liberty.

1.12G*—Section at the falls on Razor creek, one and one-half miles west of China, Jefferson County, Indiana. Saluda.

1.12H*—Section at the falls on Crooked creek, three miles north of Madison, Indiana. Saluda.

1.58A—Section on Indian Kentuck creek, half way between Canaan and Barberville, Indiana.

1.58B*—Section in the north edge of the village of Canaan, Jefferson County, Indiana. Saluda.

1.58C—One mile southwest of Canaan. Saluda.

1.59A—On Raccoon creek, one-half mile southeast of Olean, Ripley County.

1.59B—One-half mile southwest of Cross Plains, Jefferson County.

1.59C—One-half mile west of Cross Plains. Saluda.

1.59D*—One and one-half miles due west of Cross Plains. Saluda.

1.59E—Two miles due west of Cross Plains. Saluda.

1.59F—Three and one-half miles due west of Cross Plains. Saluda.

1.59G—Two miles north of Barbersville, Jefferson County. Saluda.

1.59H*—One mile north of Barbersville. Saluda.

1.60C—Headwaters of Big Graham creek southwest of Versailles, Indiana. Saluda.

1.60D—Two gulleys coming into Laughery creek from the west, one and one-half miles southeast of Versailles. Saluda.

1.60E—East bluff of Laughery creek, two miles southeast of Versailles. Saluda.

1.60F*—Cooper's falls, four miles south of Versailles. Saluda.

1.60G*—North fork of Cedar creek, north of Versailles. Waynesville.

1.60H*—West fork of Cedar creek from the base of the "Eighty-foot" cliff to the crossing of the Osgood and Versailles pike. Liberty to Whitewater.

1.60I*—Wash bank sixty feet high at the junction of the North and West forks of Cedar creek. Waynesville and base of Liberty.

1.61A*—On a small tributary of Laughery creek, one and one-half miles northeast of Osgood, Ripley County, Indiana. Saluda.

1.61B*—One and three-quarters miles northeast of Osgood. Saluda.

1.61C*—Two miles north of Osgood. Saluda.

1.61D and E—Three and one-half miles northeast of Osgood, on a small western tributary of Laughery creek. Saluda.

1.61F—Four miles north of Osgood. Clinton and Niagara.

1.61G—Three and one-half miles north of Osgood. Ordovician, Clinton contact.

1.62A to F*—Along the west branch of Laughery creek, four miles southwest of Batesville, Ripley County, Indiana. Saluda.

1.63A—Section on Harper's branch, three-quarters of a mile north of Oldenburg, Franklin County, Indiana. Liberty beds.

1.63B-D—Headwaters of a small southern tributary of Big Salt creek, one mile northwest of Oldenburg. Saluda.

1.63E*—On Big Salt creek, exactly four miles west of Oldenburg. Liberty and Saluda.

1.64A and B*—On a north tributary of Big Salt creek, two miles west of Hamburg, Franklin County, Indiana. Saluda.

1.64C—On Bull Fork, two miles northwest of Hamburg. Saluda.

1.64D*—On western tributary of Big Salt creek, three miles north of Hamburg. Saluda.

1.14A1—East end of the "Mound," three-quarters of a mile south of Laurel, Franklin County, Indiana. Top of Waynesville.

1.14A2—Railroad cut just across the river from Laurel. Base of Liberty beds.

1.14B—Big Sains creek from the junction with Little Sains creek (near Laurel) to 1.14G. Liberty beds.

1.14C, D—Three and a half miles southwest of Laurel. Liberty.

1.14F*, G*—On Big Sains creek, two miles northwest of Laurel. Saluda and Whitewater.

1.65A*—Headwaters of Duck creek, three miles northeast of Laurel. Saluda, Whitewater, Liberty.

1.66A*—On a small eastern tributary of the east fork of Whitewater river, two and a half miles southeast of Quakertown, Union County, Indiana. Liberty and Saluda.

1.67A*—At the quarry and along the small stream near the quarry, one mile west of the center of Liberty, Union County, Indiana. Liberty and Saluda.

1.41A*—Section along Elkhorn creek from the crossing of the Liberty pike to the falls, at the Boston pike. Base of Liberty to Clinton.

1.41B*—Small eastern tributary of Whitewater river, one and one-half miles south of Abington, Wayne County, Indiana. Base of Liberty.

1.41C*—Small western tributary of Whitewater river, four miles southwest of the Main street bridge at Richmond, Wayne County, Indiana. Base of Liberty.

1.41D*—At the quarries just south of the steel bridge, one and a half miles south of the Main street bridge at Richmond, and along the river to Main street. Liberty and Whitewater.

1.41E*—Along the West fork, Richmond, from its junction with East fork, to Thistlewaite Falls. Whitewater.

SECTIONS IN DETAIL.

Section in Kentucky opposite the mouth of the Miami River (5.9A).

	Ft.	In.
51—Covered to top of hill	112	..
50—Fragments of Strophomenoid shells	..	7
49—Shale	1	..
48—Limestone. Fragments of Brachiopods	..	6
47—Shale	1	..
46—Hard limestone with *Rafinesquina alternata*	..	5
45—Shale	2	4
44—Limestone. *Rafinesquina* abundant	..	5
43—Covered, probably shale	17	6
42—Shale	2	6
41—Limestone	5	2
40—Shale with thin layers of sandstone	8	6
39—Limestone with Bryozoa and *Rafinesquina alternata*	..	3
38—Mostly shale	10	8
37—Crystalline limestone. *Rafinesquina* and *Dalmanella multisecta*	9	..
36—Shale	2	3
35—Thin layers of bryozoal limestone	1	..
34—Shale	6	9
33—Bryozoal limestone	..	6
32—Shale	7	..

	Ft.	In.
31—Limestone, shale at top. *Dalmanella* (aa)	..	7
30—Covered	42	..
29—Compact highly crystalline limestone; few fossils	..	3
28—Shale	2	9
27—Highly crystalline limestone containing fragments of *Asaphus*	..	7
26—Shale	..	5
25—Compact limestone containing *Dalmanella multisecta*	..	5
24—Covered, probably some limestone	16	..
23—Brachiopod limestone (?)	..	4
22—Covered	8	4
21—Limestone. *Rafinesquina alternata* and Trilobites	..	3
20—Shale	6	4
19—Covered (probably shale)	16	..
18—Limestone (in place?)	..	6
17—Shale	10	8
16—Limestone. Bryozoa, *Plectambonites sericeus*	..	3
15—Shale	1	..
14—Limestone. *Dalmanella, Plectambonites sericeus*	..	2
13—Shale	..	7
12—Sandstone	..	3
11—Shale	2	9
10—Limestone with *Dalmanella*	..	3
9—Shale, possibly some sandy layers	5	..
8—Hard compact limestone, very few fossils	..	5
7—Shale	6	..
6—Layer of crystalline, crinoidal limestone	..	..
5—Partly covered, mostly shale	33	..
4—Sandy layer with *Trinucleus concentricus*	..	1
3—Shale	5	4
2—Limestone containing *Dalmanella multisecta* (aa*)	2	3
1—Shale to level of Ohio river	6	2
Total section	361	..

Section of the hill on the Kentucky shore opposite the mouth of the Miami River. 5.9B. (Near 5.9A.)

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
321	..	68	80	..	Nearly all covered to the top of the hill.
241	..	67	20	..	Partly covered, mostly limestone. *Platystrophia laticosta*, Bryozoa (aa).
221	..	66	0	6	Layer of limestone with *Callopora dalei* (aaa), *Zygospira cincinnatiensis*, etc.
220	7	65	15	..	Limestone and shale. *Callopora dalei* (aaa).
205	7	64	0	7	Hard fossiliferous limestone. Below this is a layer with *Callopora dalei* (aaa).

*a, abundant; aa, very abundant; c, common; r, rare.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
205	..	63	10	..	Shale and limestone. Limestone layers not so frequent as in the division below.
195	..	62	10	..	Limestone with shale partings. *Dalmanella multisecta* (aaa), *Dekayia ulrichi* (aa) in some layers.
185	..	61	10+	..	Covered.
175	..	60	6	..	About six feet shale.
169	..	59	30	..	Covered. Loose blocks evidently not far out of place contain *Dalmanella multisecta* (aa).
138	9	58	0	2	Thin layer of limestone. *Dekayia ulrichi* (aaa).
138	7	57	5	..	About five feet limestone.
133	7	56	0	2	Thin layer of limestone. *Dalmanella multisecta* (aaa), *Dekayia ulrichi* (aa).
133	5	55	7	..	Shale.
126	5	54	..	..	Thin lense of limestone with *Dekayia ulrichi*, *Peronopora vera*, and *Trinucleus concentricus*.
126	5	53	3	..	Shale.
123	5	52	0	5	Layer of limestone. Bryozoa (aaa).
123	..	51	4	..	Shale.
119	..	50	..	..	Layer of limestone.
119	..	49	10	..	Covered. Loose blocks of limestone.
109	..	48	6	..	Shale.
103	..	47	0	3	Crinoidal limestone.
102	10	46	4	..	Shale.
98	10	45	0	3	Thin layer of limestone. *Dekayia ulrichi* (aaa).
98	7	44	1	..	Shale.
97	7	43	0	3	Limestone. Small Bryozoa (aaa).
97	4	42	2	6	Shale.
94	10	41	0	4	Very fossiliferous limestone. *Bythopora arcti-pora*, *Callopora onealli*, *Dalmanella multisecta*, etc.
94	6	40	2	4	Shale.
92	2	39	0	1	Very thin layer of sandstone.
92	1	38	4	..	Shale.
88	1	37	0	1	Very thin layer of sandstone.
88	..	36	5	..	Shale.
83	..	35	0	4	Fossiliferous limestone. *Dalmanella multisecta*.
82	7	34	15	..	Shale slighty obscured by fallen blocks of limestone.
67	7	33	1	..	Limestone with shale partings.
66	7	32	0	10	Shale.
65	9	31	0	2	Limestone layer. *Dalmanella multisecta* (aa).
65	7	30	1	7	Shale.
64	..	29	0	3	Very fossiliferous limestone. *Callopora onealli*, *Dekayia ulrichi*, *Batostoma* sp., *Dalmanella multisecta*.
63	10	28	1	..	Shale.
62	10	27	0	2	Limestone.
62	8	26	0	6	Shale.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
62	2	25	0	4	Sandstone layer.
61	10	24	1	3	Shale.
60	7	23	1	2	Sandy layer.
59	5	22	0	3	Shale.
59	2	21	0	2	Layer of sandstone.
59	..	20	0	10	Shale.
58	3	19	0	3	Very fossiliferous limestone. *Dalmanella multisecta* (aaa), *Plectambonites sericeus* (c), *Calymene callicephala*, annelid jaws and crinoid segments, both abundant.
58	..	18	1	5	Shale.
56	7	17	0	2	Blue, hard, crystalline, fine-grained limestone.
56	5	16	4	..	Shale.
52	5	15	0	5+	Crystalline barren limestone.
52	..	14	3	5	Shale with two thin sandstone layers.
48	9	13	0	1	Thin layer of sandstone.
48	8	12	2	..	Soft shale.
46	8	11	0	1	Thin laminated sandstone layer.
46	7	10	5	..	Shale.
41	7	9	11	..	Partly covered. Small exposures of blue shale.
30	7	8	0	2	Thin layer of limestone.
30	5	7	5	..	Shale.
25	4	6	0	1	Crinoidal limestone.
21	4	5	4	..	Shale.
21	2	4	0	2	Layer of sandstone.
1	2	3	20	..	Shale with occasional thin layers of soft sandstone.
1	2	2	0	2	Layer of coarse grained limestone with *Trinucleus concentricus*, *Bythopora arctipora*, and *Dalmanella multisecta*.
1	..	1	1	..	Shale to the level of the Ohio river.

Section of the High Hill just west of Lawrenceburg, Indiana. 1.33A.

390	..	5	90	..	Covered to the top of the hill at the Bockhorst house.
300	..	4	32	..	Upper heavy projecting layers in the road metal quarry. *Platystrophia laticosta*, *P. lynx*, *Hebertella sinuata*, *Callopora ramosa*, *Callopora rugosa*, *Bythopora gracilis*. Same zone as 1.34C 14b.
268	..	3	13	..	Exposed between the talus and the base of the heavy layers. More shaly. Fauna same as above.
255	..	2	40	..	Covered by the talus from the cliff above. Fossils from the upper layers are very abundant in the talus.
215	..	1	215	..	Nearly all covered to the level of the Tanner's creek at the bridge across the Lawrenceburg and Aurora pike.

The exposed portion of this section is all higher than any of the exposed portion of the section opposite the mouth of the Miami River. The two sections together show nearly 100 feet of the Lorraine. The level of the creek at the base of this section is approximately the level of the Ohio River. Fossils listed 1.33A3 are from Nos. 3 and 4 of this section.

The fauna of 1.33A3 is as follows: *Callopora ramosa, C. rugosa, C. dalei* (?), *C. andrewsi, Bythopora gracilis, Dekayia frondosa, D. inflecta, D. magna, Homotrypa curvata, H. obliqua, Peronopora pavonia, Monticulipora molesta, Atactoporella mundula, A. ortoni, Petigopora gregaria, P. petechialis, Arthropora Schafferi, Escharopora sp., Aspidopora sp., Ceramoporella ohioensis, Stomatopora inflata, Proboscina frondosa, P. auloporoides, Rafinesquina alternata, R. fracta, R. ponderosa, R. nasuta, Platystrophia laticosta, P. lynx, Hebertella sinuata, Zygospira modesta, Allonychia jamesi, Cyclonema sp., Orthoceras sp.,* and several unidentifiable species of gastropods and crinoids.

Detailed Section of the Hill Back of Vevay, Indiana, Beginning at the Head of Main Cross Street, and Extending up the Gulley to Near the Top of the Hill. Nos. 86 to 88 are Along the Old Road Over the Top of the Hill.
1.38 A and B.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
390	..	88	27	..	Heavy, compact limestone. Few fossils.
363	..	87	49	..	Thin, shaly limestone. *Platystrophia lynx, P. laticosta, Hebertella sinuata, Callopora ramosa, Callopora rugosa, Monticulipora mammulata.*
313	..	86	9	..	Shaly limestone same as that above. *Hebertella sinuata, Platystrophia laticosta.*
303	10	85	0	4	Yellowish argillaceous sandstone.
303	6	84	12	..	Thin bedded limestone, containing *Platystrophia laticosta, Hebertella sinuata, Plectorthis plicatella, Escharpora falciformis, Constellaria constellata.*
291	6	83	0	6	Thicker layer of limestone. *Platystrophia laticosta, Constellaria constellata.*
291	..	82	0	4	Yellow sandy layer.
290	7	81	3	3	Covered.
287	4	80	0	4	Argillaceous-arenaceous limestone.
287	..	79	14	..	Some covered. Mostly thin layers of limestone.
273	..	78	0	5	Limestone. *Rafinesquina alternata* and *Bryozoa.*
272	6	77	3	8	Covered.
268	10	76	0	4	Compact limestone.

Total Thickness Ft.	In.	No.	Thickness of Bed. Ft.	In.	
268	6	75	0	6	Covered.
268	..	74	3	8	Coarse grained limestone.
264	3	73	1	3	Limestone. *Platystrophia laticosta, Escharopora pavonia.*
263	..	72	0	4	Coarse grained crinoidal limestone. *Rafinesquina alternata* (c).
262	9	71	3	..	Covered.
259	9	70	0	3	Fine grained limestone.
259	6	69	0	6	Shale.
259	..	68	0	5	Coarse grained limestone. *Rafinesquina alternata* (aa).
258	8	67	1	8	Covered.
257	..	66	1	..	Thick bedded, light gray limestone containing fragments of *Rafinesquina alternata* in abundance.
256	..	65	8	..	Thin bedded bryozoal limestone. *Callopora dalei, Dekayia ulrichi, Platystrophia laticosta* very small form. *Hebertella sinuata.*
248	..	64	6	..	Covered.
242	..	63	0	6	Bryozoal limestone. *Dekayia ulrichi, Callopora dalei, Platystrophia laticosta* very small form.
241	6	62	0	8	Covered.
240	10	61	1	2	Limestone. *Callopora dalei, Dalmanella multisecta.* Top of the DALMANELLA MULTISECTA ZONE.
239	8	60	8	8	Covered.
231	8	59	0	4	Dark, drab limestone. *Peronopora vera, Dekayia ulrichi, Callopora communis, Dalmanella multisecta.*
231	4	58	2	..	Covered.
229	4	57	0	7	Compact limestone. *Dalmanella multisecta* (aa).
228	9	56	25	..	Covered. (A recent restudy of this section revealed several exposed layers in this interval, containing *Dalmanella multisecta* in abundance.)
203	9	55	0	6	Coarse grained crystalline limestone. Fragments of *Dalmanella multisecta* and *Rafinesquina alternata* abundant.
203	3	54	0	6	Shale.
202	9	53	0	3	Limestone. *Dalmanella emacerata* (r).
202	6	52	0	10	Shale.
201	8	51	0	3	Gray limestone. *Dekayia ulrichi* (c).
201	5	50	2	8	Shale.
198	9	49	0	6	Coarse grained limestone. *Dalmanella multisecta. Coeloclema* sp. *Callopora.*
198	3	48	1	..	Shale.
197	3	47	0	3	Yellowish limestone.
197	..	46	2	..	Shale.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
195	..	45	5	..	Thin layers of limestone. *Coeloclema, Peronopora vera, Callopora communis, Bythopora arctipora, Dekayia ulrichi, Zygospira cincinnatiensis, Dalmanella multisecta.*
190	..	44	2	3	Shale.
187	8	43	0	6	Layers of calcareous sandstone.
187	2	42	3	..	Shale.
184	2	41	0	2	Limestone. *Batostoma* sp., *Dekayia ulrichi* (c), *Callopora communis, Bythopora arctipora.*
184	..	40	3	8	Shale.
180	6	39	0	8	Crinoidal limestone. *Dekayia ulrichi, Callopora communis.*
179	10	38	5	..	Shale.
174	10	37	2	6	Bryozoal limestone in thin layers. *Dekayi ulrichi* (aa), *Coeloclema commune* (a), *Stigmatella clavis, Callopora communis, Batostoma implicatum, Zygospira cincinnatiensis.*
172	4	36	2	6	Shale and thin limestones.
169	10	35	5	..	Bryozoal limestone. *Dekayia ulrichi, Dalmanella multisecta.*
164	10	34	2	..	Shale.
162	10	33	0	10	Hard limestone. *Bythopora arctipora, Batostoma implicatum, Dalmanella multisecta, Zyospira cincinnatiensis.*
162	..	32	2	4	Thin limestone and shale. *Callopora onealli-sigillaroides, Bythopora arctipora, Dekayia ulrichi, Batostoma implicatum, Dalmanella multisecta.*
159	7	31	0	4	Limestone. *Coeloclema* sp., *Ceramoporella ohioensis, Peronopora vera, Callopora onealli* var., *Batostoma implicatum, Escharopora acuminata, Dalmanella multisecta, Trinucleus concentricus.*
159	3	30	1	8	Shale.
157	7	29	0	7	Limestone with argillaceous material in spots. *Callopora communis?, Atactoporella* sp., *Dalmanella multisecta, Retzia granulifera.*
157	..	28	0	8	Shale.
156	4	27	0	4	Sandstone.
156	..	26	6	3	Shale with thin layers of limestone.
149	8	25	0	4	Dark crystalline limestone.
149	4	24	5	4	Shaly limestone. *Ceramoporella distincta, Callopora communis, Bythopora arctipora, Batostoma implicatum, Peronopora vera, Dekayia ulrichi?, Dalmanella emacerata, Zygospira cincinnatiensis, Acidaspis ceralepta.*

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
144	..	23	0	7	Crinoidal limestone. *Coeloclema commune, Batostoma implicatum, Bythopora arctipora, Peronopora vera, Dalmanella emacerata, Zygospira cincinnatiensis, Dalmanella multisecta, Trinucleus concentricus.*
143	4	22	2	6	Shale.
140	10	21	0	3	Limestone. *Coelclema commune* (aaa), *Callopora communis?, Bythopora arctipora, Dekayia ulrichi, Dalmanella emacerata, Plectorthis* sp.
140	7	20	0	7	Shale.
140	..	19	1	..	Thin layers of limestone with intercalated shale. *Peronopora vera, Dalmanella multisecta* (aa), *Zygospira cincinnatiensis, Dalmanella emacerata.*
139	..	18	7	..	Shale.
132	..	17	0	3	Limestone. *Batostoma implicatum, Peronopora vera, Bythopora arctipora, Dalmanella multisecta.*
131	10	16	2	6	Shale.
129	4	15	0	6	Compact limestone. *Batostoma implicatum, Dekayia obscura, D. ulrichi, Dalmanella multisecta.*
128	10	14	0	5	Shale.
128	5	13	0	5	Compact limestone. *Coeloclema alternatum* (c); *Bythopora arctipora, Callopora sigillaroides, Dekayia ulrichi, Callopora communis, Dalmanella multisecta, Batostoma implicatum.*
128	..	12	6	4	Shale with occasional thin layers of limestone.
121	9	11	0	3	Limestone mottled with argillaceous material. *Callopora onealli, C. nodulosa, Batostoma implicatum, Peronopora vera, Coeloclema alternatum* (a), *Bythopora arctipora* (c), *Dekayia ulrichi, Dalmanella multisecta, Plectambonites sericeus, Proetus* sp.
121	6	10	2	3	Shale with occasional thin even layers of limestone.
119	3	9	1	..	Thin layers of fine grained compact limestone. *Callopora onealli, Batostoma implicatum, Dalmanella multisecta.*
118	3	8	1	..	Shale.
117	3	7	0	5	Limestone mottled with argillaceous spots. *Batostoma implicatum, Peronopora vera, Dalmanella multisecta.*
116	10	6	4	..	Shale.
112	10	5	0	10	Dark blue limestone. *Coeloclema alternatum, Callopora onealli, Bythopora arctipora, Dalmanella multisecta.*
112	..	4	4	6	Shale.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
107	6	3	0	6	Dark blue limestonee containing *Dalmanella multisecta* (c), and *Plectambonites sericeus* (c).
107	..	2	6	..	Soft blue shale exposed at the mouth of the gully near the Orphan Asylum at the head of Main Cross street.
101	..	1	101	..	Covered to the level of the Ohio river.

The top of the Eden shales in this section is considered to be where the characteristic *Dalmanella multisecta* leaves off, namely, at No. 61, although a few specimens of *Dekayia ulrichi* are found in the fifteen feet above this. *Platystrophia laticosta* comes in immediately above this, and *Hebertella sinuata* within a few feet. The top of the *Platystrophia* zone is apparently reached at the top of No. 87, 123 ft. above the top of the Eden. The complete faunal lists of this section are given in a paper by the writer, published in the American Geologist, December, 1901.

Section of the Hill Above the Cemetery, One Mile Northeast of Vevay. 1.38G.

390	..	5	40	..	Mostly covered to the extreme top of the hill at an old log house.
350	..	4	78	..	Limestone and shale containing numerous specimens of *Platystrophia lynx*, and *Hebertella sinuata*. The former more abundant in the upper part and the latter in the lower.
272	..	3	25	..	Several layers in this division contain immense numbers of *Callopora communis* and *C. dalei*, and occasional specimens of a small *Platystrophia* allied to *P. laticosta*. The base of this division is formed by the lowest layer containing the *Callopora*. *Constellaria constellata* is another common fossil in this division. This is the lowest division of the Lorraine.
247	..	2	167	..	Mostly covered to the level of the pike at the foot of the hill. *Dalmanella multisecta* is the common fossil.
80	..	1	80	..	Covered to river level.

Section in the Gully that Heads at the Culvert 210 Feet North of the North End of the South Cut on the P., C., C. & St. L. R. R., Madison. 1.12A.

197	..	45	10	..	Soft, blue shale. The top of this division and of the section is at the top of the stone butment of the culvert 210 feet north of the north end of the south cut.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
187	..	44	1	2	Several layers of limestone with *Cyclonema, Calymene callicephala, Rafinesquina alternata*, etc.
186	..	43	2	8	Shaly limestone.
183	3	42	2	..	Crinoidal limestone. Bryozoa, *Rafinesquina.*
181	3	41	5	..	Limestone and shale.
176	3	40	0	3	Compact, close grained limestone. *Rafinesquina.*
176	..	39	2	4	Limestone and shale. *Zygospira modesta.*
173	7	38	0	4	Limestone. *Rafinesquina* (aaa) edgewise.
173	3	37	6	9	Argillaceous compact limestone. *Rafinesquina.*
166	6	36	0	6	Limestone. Bryozoa (a).
166	..	35	5	8	Shaly limestone.
160	4	34	0	8	Limestone.
159	8	33	2	8	Shaly limestone.
157	..	32	0	8	Limestone. *Rafinesquina*, Gastropoda, Bryozoa.
156	4	31	10	8	Shale with occasional 2 feet to 3 feet layers of limestone.
145	8	30	0	3	Limestone. *Rafinesquina* edgewise (aaa).
145	5	29	6	9	Shaly limestone. *Rafinesquina* (aa), *Modiolodon* (aa), *Zygospira modesta* (aa).
138	8	28	0	4	Blue fine grained limestone. *Zygospira modesta* (aaa).
138	4	27	1	4	Shaly limestone.
137	..	26	0	3	Blue fine grained limestone. *Zygospira modesta* (aaa).
136	8	25	13	..	Shaly limestone. *Rafinesquina*, etc.
123	8	24	0	6	Very compact, fine grained limestone. No fossils.
123	2	23	4	2	Shale and limestone with excellently preserved specimens of *Rafinesquina alternata* (aa).
119	..	22	0	3	Limestone with top layer composed of immense numbers of *Zygospira modesta.*
118	8	21	2	..	Rather coarse shale.
116	8	20	3	..	Lumpy, shaly limestone.
113	8	19	0	8	Coarse to fine grained barren limestone.
113	..	18	12	..	Lumpy, shaly limestone. *Rafinesquina alternata, Zygospira modesta, Calymene callicephala*, Bryozoa.
101	..	17	5	10	Limestone. *Rafinesquina, Zygospira modesta* (aa).
95	2	16	1	..	Shale with thin layers of limestone.
94	2	15	0	6	Very compact, fine grained, blue, barren limestone.
93	8	14	0	8	Shale.
93	..	13	0	5	Compact limestone. *Calymene callicephala, Zygospira modesta.*
92	6	12	1	3	Limestone. *Calymene callicephala* (aa), *Rafinesquina*, Bryozoa.
91	3	11	3	8	Shale with thin layers of limestone.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
87	7	10	1	..	Thin argillaceous limestone. Bryozoa (aa).
86	7	9	0	7	Massive blue limestone.
86	..	8	2	9	Limestone. *Rafinesquina, Zygospira modesta,* Bryozoa.
83	2	7	1	..	Thin, argillaceous, yellow-spotted limestone. *Platystrophia laticosta, Hebertella sinuata.*
82	2	6	1	2	Limestone. *Hebertella* (aa), *Platystrophia lynx, Rafinesquina nasuta.*
81	..	5	0	4	Bryozoal limestone.
80	8	4	1	..	Shale.
79	8	3	0	2	Limestone.
79	6	2a	0	6	Coarse crystalline limestone. *Hebertella sinuata.*
79	..	2	20	..	Thin limestone and shale, very fossiliferous. *Platystrophia lynx, P. laticosta, Hebertella sinuata, Dekayia frondosa, Monticulipora mammulata, Callopora ramosa, C. rugosa* are the common fossils. This division is exposed in the creek into which the gully empties, at a point several hundred feet down stream.
59	..	1	59	..	Covered to the low water level of the Ohio river.

The base of the exposed portion of this section represents the middle part of the Lorraine—apparently the equivalent of the Bellevue beds of Nickles. These beds comprise Nos. 2 to 7 of the section, a thickness of about 24 ft. The balance of the section, 114 ft. in thickness, falls in the *Rafinesquina* zone of this report, which is about equivalent to the Corryville, Mt. Auburn and Arnheim of Nickles and Foerste. In the present section there is no representative of the Mt. Auburn (*Platystrophia lynx*) beds. Very careful search fails to reveal a single specimen of the gerontic *P. lynx,* or any other form of that species above number 7 of the section. This 114 ft. does not represent the entire thickness of this division, in this locality, since about 20 ft. of rock is exposed in the north end of the south cut above this section, and below the *Dalmanella meeki* zone. It appears, therefore, that the interval between the top of the *Platystrophia* zone and the base of the *Dalmanella meeki* zone is at least 134 ft. This section, with the exception of numbers 1 and 2, was measured layer by layer with the tape.

The fauna of No. 1.12A2 is as follows: *Callopora ramosa* (c), *C. rugosa* (c), *Monticulipora mammulata, Pronopora pavonia, Dekayia frondosa, Bythopora gracilis, Atactoporella ortoni, Ceramoporella ohioensis, Stomatopora inflata, S. arachnoidea, Arthropora schafferi, Platystrophia lynx* (normal form *aa*), *P. laticosta, P. cypha, Hebertella sinuata* (c), *Rafinesquina ponderosa, R. nasuta,* *Plectorthis* sp., *Zygospira modesta, Crania scabiosa, Byssonychia* cf. *praecursa, Cyclora minuta, Orthoceras* sp., *Isotelus maximus, Conchiolites flexuosus, Acidaspis* sp.

Section of the South Cut at Madison, Indiana, Beginning at the Track Level at the South End of the Cut and Terminating at the Extreme Top of the Exposed Rock in the Cut. 1.12E.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
83	..	3	30	..	Heavy brown-weathering layers seen at the top of the west side of the cut. These layers contain *Dalmanella meeki* in great abundance, especially in the upper part.
53	..	2	37	6	Conspicuous brown-weathering layers seen in the east side of the cut at the north end and underlying the layers of No. 3 in the west side of the cut. Practically all of this division is repeated in the top of Section 1.12A.
15	6	1	15	6	Shale and heavy layers of limestone. Practically all covered by talus in the south end of the cut.

The fauna of No. 1.12E3 is as follows: *Dalmanella meeki* (aaa), *Rafinesquina alternata, Zygospira modesta, Leptaena rhomboidalis, Strophomena planumbona, Platystrophia laticosta, Hebertella sinuata, Plectambonites sericeus* (r), *Crania* sp., *Dicranopora emacerata, Arthropora schafferi, Peronopora pavonia, Dekayia prolifica, Homotrypa* cf. *austini, Batostoma varians, Eridotrypa simulatrix, Ceramoporella ohioensis, Rhombotrypa quadrata, Prasopora hospitalis, Bythopora delicatula, B. meeki, Callopora subnodosa, Bernicea primitiva, Stomatopora* sp., *Nicholsonella vaupeli, Tentaculites richmondensis, Acidaspis* sp., *Isotelus* sp., *Cyclonema bilix, Anomalodonta gigantea, Opisthoptera casei, Ctenodonta cingulata* (?).

Section at the Sharp Bend of the Road a Little Way Below the Hanging Rock, Madison. 1.12F.

..	..	4	..	..	*Columnaria* reef.
55	..	3	35	..	Limestone with shale partings. Contains a typical Liberty fauna.
20	..	2	20	..	Shale and limestone. Nearly all covered by talus from above.
..	..	1	..	..	Covered to river level, about 260 feet.

The fauna of No. 1.12F3 is as follows: *Rhynchotrema capax, Dinorthis subquadrata* (c), *Strophomena planumbona* (c), *Strophomena neglecta, Rafinesquina alternata, Hebertella occidentalis, H.*

Fig. 2. View of the Big (North) cut at Madison, Indiana. The heavy, overhanging layers in the upper part of the right hand (west) side of the cut represent the massive sandstone bed of the base of the Saluda. The base of this bed is the layer *a*. The layer *b* is the top of the fossiliferous limestones and shales.

sinuata, H. sp., *Zygospira modesta, Plectambonites sericeus, Platystrophia acutilirata* (*rr*), *P. laticosta, Strophomena subtenta* (r), *Dicranopora emacerata, Arthropora schafferi, Bythopora delicatula, B. meeki, B. striata, Callopora subnodosa, C.* sp. (with sharp monticules like *C. ramosa*), *Ceramoporella ohioensis, Prasopora hospitalis, Homotrypa ramulosa* (?), *H.* cf. *cylindrica, Rhombotrypa quadrata, Constellaria polystomella, Helopora* sp., *Isotelus* sp., *Calymmene callicephala, Acidaspis* sp., *Protarea vetusta, Streptelasma rusticum, Pterinea demissa, Ischyrodonta* sp., *Ortonella hainesi* (??), *Byssonychia suberecta, Cycloconcha milleri, Opisthoptera casei, Conradella dyeri, Poteriocrinites polydactylus, Glyptocrinus* sp. (plates of calyx), *Crania laelia* (rr).

Section of the Big Cut (North Cut) Madison, Indiana. 1.12D.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
146	9	24	10	..	Massive, hard, whitish limestone with numerous small cavities.
136	9	23	5	..	Massive blue limestone, full of small cavities or pits.
131	9	22	5	..	Thin layers similar to No. 23.
126	9	21	2	6	Blue shale.
124	3	20	3	10	White massive limestone, somewhat argillaceous at the top and more calcareous at the base.
120	5	19	8	3	Shale.
112	2	18	2	6	Massive white limestone. Base of the NIAGARA.
109	8	17	1+	..	Pink to salmon colored, coarse, crystalline limestone. This is the representative of the CLINTON formation.
108	8	16	4	2	Massive light colored arenaceous limestone.
104	6	15	9	8	Thick-bedded, soft, argillaceous-arenaceous limestone. (Calcareous sandstone.)
94	10	14	12	10	Argillaceous-arenaceous, somewhat calcareous thick bed. On the weathered surface streaked or banded with various colors—ash gray, buff. pink, etc. On fresh surface light brown.
82	..	13	3	6	One massive, conspicuous arenaceous layer. This forms the base of the prominently overhanging bed in the upper part of the cut.
78	6	12	7	..	Thin-bedded argillaceous-arenaceous, brownish weathering layers with calcareous streaks containing bryozoa.
71	6	11	0	4	Nothing to four inches of coarse limestone with numerous fossils. *Hebertella*, etc.
71	2	10	3	..	Arenaceous bed with lenticles of limestone containing fossils, mostly bryozoa.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
68	2	9	2	..	Limestone containing numerous large examples of *Columnaria alveolata.* Upper Columnaria reef. This layer runs under the tracks at the extreme north end of the big cut.
66	2	8	6	..	Shale.
60	2	7	1	2	Limestone containing numerous large examples of *Columnaria alveolata.* Lower Columnaria reef.
59	..	6	5	3	Thin layers of limestone alternating with argillaceous and sandy layers. The limestone layers contain numerous bryozoa and *Hebertella occidentalis*, and *Rafinesquina alternata.*
53	8	5	7	8	Arenaceous-argillaceous bed, massive in appearance on fresh exposure.
46	..	4	6	..	Blue, fossiliferous limestone, shale and some arenaceous layers.
40	..	3	10	..	Thin limestone layers with intercalated soft shale. *Rhynchotrema capax, Hebertella occidentalis, Strophomena planumbona, Streptelasma rusticum, Dinorthis subquadrata, Strophomena neglecta, Platystrophia acutilirata* (r) are the characteristic fossils.
30	..	2	8	..	Similar to No. 3, but with numerous specimens of *Plectambonites sericeus* in some layers.
22	..	1	22	..	Probably mostly shale with thin layers of limestone. Obscured by the talus from the higher layers. Base at the iron pipe on the west side of the tracks at the extreme south end of the cut.

The thickness of the Saluda beds in the present section, if the lower Columnaria reef (which corresponds to the lower Tetradium reef in the sections farther north) be taken as the base, is 50 feet (49 feet 8 inches). The thickness of the same division at Cooper's falls near Versailles is 58 feet. One and three-quarters miles south of Versailles the thickness is 53 feet. Near Osgood the thickness is between 60 and 70 feet.

The thickness of the Liberty division in the Madison section, if the *Plectambonites* horizon in the above section be taken as the base, is about 30 feet. It is also about 30 feet in the Versailles section. If the first appearance of *Hebertella insculpta* be taken as the base of the Liberty, its thickness will be about 10 or 15 feet more. In the Richmond section the Liberty division is 40 feet thick and the Saluda, Whitewater and Elkhorn 130 feet. It is evident, therefore, that the thinning of the upper Richmond beds in the Madison section is due to the absence of the Whitewater division and not to the thinning of the other divisions, as has been commonly supposed.

The fauna of No. 1.12D1-6 is as follows: *Strophomena planumbona* (c), *S. neglecta* (c), *S. sulcata* (r), *Hebertella occidentalis* (c), *Rafinesquina alternata, Zygospira modesta, Plectambonites sericeus, Rhynchotrema capax* (c), *Dinorthis subquadrata* (c), *Platystrophia laticosta, Hebertella sinuata, Crania scabiosa, Leptaena rhomboidalis* (r), *Dalmanella meeki* (rr), *Platystrophia acutilirata, Dicranopora emacerata, Arthropora schafferi, Prasopora hospitalis, Callopora* sp. (sharp monticules), *Bythopora meeki, B. striata, Batostoma variabile, Stomatopora arachnoidea, Constellaria* sp., *Calymmene callicephala, Isotelus* sp., *Pterinea demissa, Conradella dyeri, Streptelasma rusticum, Byssonychia* sp.

Section at the Hanging Rock, Madison.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
46	..	2	19	..	Upper argillaceous bed. The top of this division is formed by the Clinton limestone, and the base by the calcareous layer that forms the lower crest of the falls at the north end of the big cut.
27	..	1	27	..	From the calcareous layer to the upper *Columnaria* reef. Argillaceous sandstone with calcareous streaks.

The measurements here were made with the tape.

Section of the Falls in the Small Gully West of the Railroad Tracks, Just North of the Big Cut, Madison, Indiana.

45	..	6	1	3	Clinton limestone.
43	10	5	4	..	Mottled limestone forming upper crest of falls.
39	10	4	15	..	Mottled, rather soft, ash colored shaly sandstone. Somewhat calcareous.
24	10	3	2	10	Strong calcareous layer. Forms the lower crest of the falls.
22	..	2	15	..	Massive soft sandstone. Forms the conspicuous overhanging rocks in the cut.
7	..	1	7	..	Soft, sandy shale with calcareous streaks. This bed is underlain by the upper *Columnaria* reef.

Measurements with the tape.

General Section of the Cuts on the P., C., C. & St. L. R. R. at Madison, Indiana. 1.12A, E and D.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
467	..	8	107	..	From the top of the Clinton limestone to the level of the tracks at North Madison.
360	..	7	45	..	From the upper *Columnaria* reef at the extreme north end of the north cut (big cut) to the Clinton limestone.
315	..	6	65	..	From the level of the tracks at the south end of the big cut to the level of the upper *Columnaria* reef at the north end of the big cut.
250	..	5	54	..	From the level of the top of Section A to the level of the tracks at the south end of the big cut.
196	..	4	11	..	From the level of the tracks at the north end of the south cut to the top of Section A (level of the top of the stone butment of the culvert 210 feet north of the north end of the cut).
185	..	3	47	..	From the level of the tracks at the south end of the south cut to the level of the tracks at the north end of the south cut.
138	..	2	88	..	From the level of the railroad tracks at the bottom of the grade at Madison to the level of the tracks at the south end of the south cut.
50	..	1	50	..	From the low water level of the Ohio river at Madison to the level of the railroad tracks at the foot of the grade.

This section is made up from the data supplied by the engineer of the P., C., C. & St. L. R. R., in regard to the per cent. of grade and the distances through the cuts and between the cuts; and from measurements of the distance from the beginning of the grade at Madison to the south end of the south cut, and of the distance from the north end of the big cut to the top of the grade at North Madison; and from the data given in Gannett's dictionary of altitudes (fourth edition) in regard to the elevation of the low water of the Ohio river, elevation of the railroad at Madison and elevation of the railroad at North Madison. The elevation of the Clinton limestone above the north end of the big cut was determined by measurement with a tape and the barometer. The data thus obtained are as follows:

Low water level of the Ohio river 401 feet A.T.; elevation of the railroad at Madison, 450 feet A.T.; elevation of the railroad at North Madison, 877 feet A.T.; per cent. of grade, 5.89 per cent.; distance from the foot of the grade at Madison to the south end of the south cut, 1,500 feet; distance through the south cut, 800 feet; distance from the north end of the south cut to the top of section A (culvert just north of the south cut), 210 feet; distance from the top of section A to the south end of the big cut (north cut), 890 feet; distance through the big cut, 1,100 feet; distance from the north end of the big cut to the top of the grade at North Madison, 2,580 feet. Total distance from the foot of the grade at Madison to the top of the grade at North Madison, 7,080 feet. Difference in elevation between Madison and North Madison obtained by multiplying this distance by the per cent. of grade (70.8x5.89), 417 feet. Difference in elevation between Madison and North Madison according to Gannett's dictionary of altitudes, 427 feet. This small discrepancy is probably due to slight inaccuracy in the determination of the top of the grade at North Madison and the bottom of the grade at Madison. With this section the barometric measurements taken at several different times are in fair agreement. The average of these barometric measurements give the difference in elevation between Madison and North Madison as approximately 400 feet. The elevation of the railroad at North Madison above river level as obtained by Locke level in 1900 is 473 feet. This differs from the elevation according to Gannett's figures by only 4 feet. The elevation of the south end of the south cut above river level according to measurements with the Locke level made in 1900 is 140 feet. This differs from the elevation obtained by computation from the per cent of grade by only 2 feet.

Section Along the North Fork of Razor Creek Five Miles North of Madison. 1.12G.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
50	8	8	2	4	Pink, coarse grained *Clinton* limestone.
48	4	7	10	..	Mottled impure soft limestone, forming six ledges with shale partings. Weathers gray, mottled with dark specks and with a flaky surface.
38	4	6	4	4	Heavy, harder layers forming the crest of the upper part of the falls. Mottled crystalline limestone.
34	..	5	5	4	Arenaceous, shaly, soft, blocky limestone.
28	8	4	2	2	Impure crystalline limestone, mottled with yellow specks. Forms the crest of the lower part of the falls.
26	6	3	16	..	Arenaceous shale. "Shale bed." The upper layer, 1 foot 3 inches thick, is especially arenaceous.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
10	6	2	1	..	Hard, massive layer of limestone.
9	6	1	9	6	Blocky limestone with *Tetradium* throughout. *Columnaria* occurs at the base near the water level.

Section in the North Edge of the Village of Canaan. 1.58B.

47	..	4	29	..	Ordovician-Clinton contact. Limestone becoming shaly and arenaceous in the lower part.
18	..	3	11	..	"Shale bed." Base decidedly arenaceous.
7	..	2	5	..	Interval between the shale bed and the *Tetradium* reef.
2	..	1	2	..	*Tetradium* reef at the top; *Columnaria* reef at the bottom. Between this locality and Osgood the *Columnaria* does not seem to be present, or at least is very rare.

Section in an Eastern Tributary of the East Fork of Indian Kentuck Creek, Four Miles Southwest of Cross Plains. 1.59H.

67	..	13	6	..	Brownish, concretionary limestone. The Clinton rests directly upon this division.
61	..	12	2	..	*Tetradium.*
59	..	11	4	..	Hard, fine-grained limestone, thinner than Nos. 8 and 9.
55	..	10	1	..	Thick, wave-marked layer.
54	..	9	1	6	Same as No. 8, with shale partings.
52	6	8	0	6	Hard, dove colored, fine-grained, white weathering layer.
52	..	7a	14	..	Thin, impure, lumpy layers of limestone, gray, somewhat mottled; somewhat ripple marked.
38	..	7	1	..	Conspicuous hard limestone layer.
37	..	6	10	..	Soft, gray, mottled, uneven, lumpy limestone. Few fossils.
27	..	5	8	..	Soft, blocky, dark, jointed shale, somewhat ripple marked but not so arenaceous as the shale bed below.
19	..	4	0	6	Hard layer of limestone.
18	6	3	2	6	A one-foot layer of hard, blue limestone overlain by shale.
16	..	2	11	..	Ripple-marked and sun-cracked shale. "Shale bed." An arenaceous, heavy bed at the base.
5	..	1	5	..	Massive, hard layer of limestone underlain by soft shale. The base of this division is formed by the lower *Tetradium* reef.

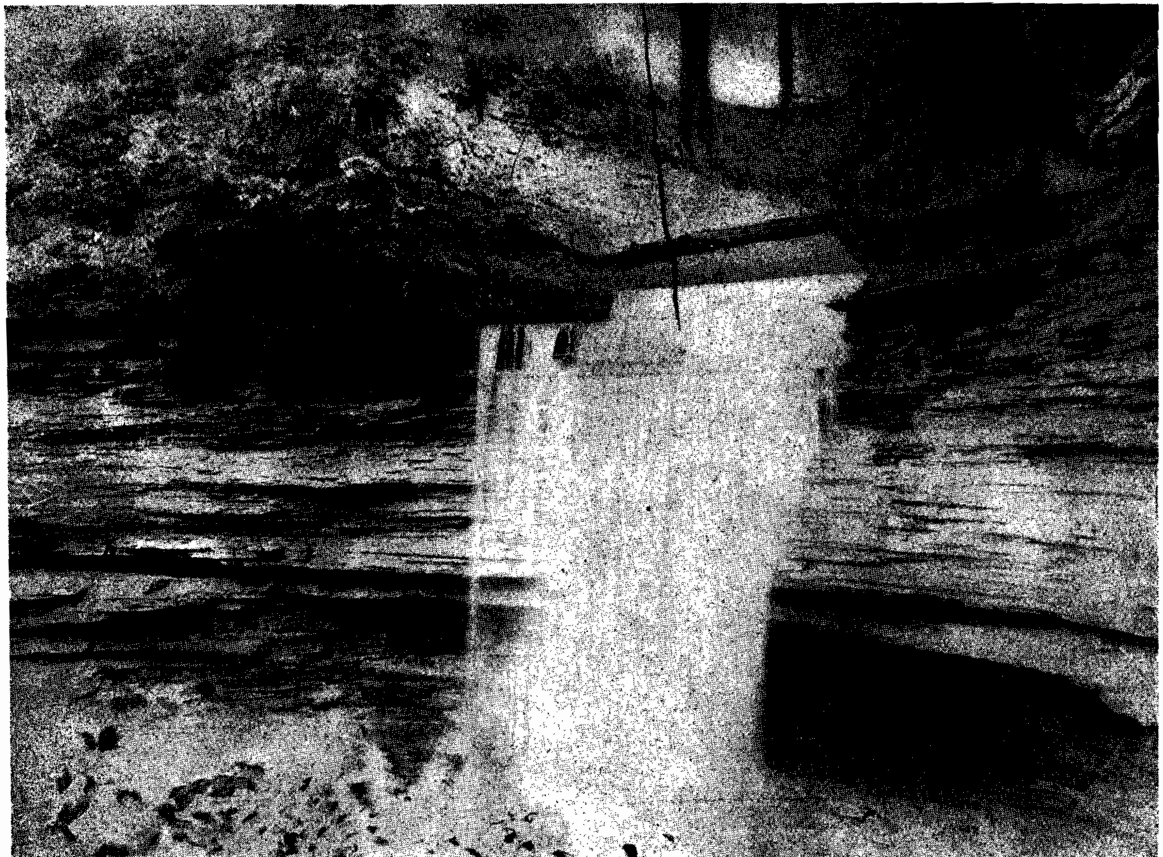

Fig. 3.—Cooper's Falls, four miles south of Versailles. The top of the "shale bed" is at *a* and the base at *b*.

Section in a Gully Entering the East Fork of Indian Kentuck Creek from the East, Four Miles Southwest of Cross Plains. 1.59G.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
58	6	5	38	..	Limestone and shale. The layers immediately under the Clinton are hard and light colored. Toward the lower part of the division the rock is more argillaceous, and somewhat inclined to be ripple marked like the shale bed.
20	6	4	15	..	Ripple-marked and sun-cracked shale. "Shale bed." Somewhat arenaceous.
5	6	3	0	8	Hard limestone layer.
4	10	2	1	10	Soft, even light colored shale.
3	..	1	3	..	Blocky shale and limestone. Base formed by the lower *Tetradium* reef.

Section Three and One-Half Miles Southwest of Olcan (in the Gully that Crosses the East-West Road Two Miles Due West of Cross Plains). 1.59D.

43	..	3	15	..	Limestone. Directly overlain by the Clinton limestone.
28	..	2	15	..	Top of this division is the upper *Tetradium* reef. Mottled soft limestone and shale. More argillaceous than the same division farther north. The base of this division is formed by the massive hard limestone that commonly overlies the shale bed.
13	..	1	13	..	Slabby, sun-cracked and ripple-marked drab shale. The "Shale bed." The base is formed by a hard layer of limestone, and this is overlain by about two feet thickness of more arenaceous rock than is seen farther north at this horizon.

Section of Cooper's Falls, Four Miles South of Versailles. 1.60F.

58	..	4	30	..	From the base of the Clinton to the crest of the falls. Limestone.
28	..	3	5	..	From the crest of the falls to the top of the shale bed. Limestone.
23	..	2	10	..	Sun-cracked and ripple-marked shale. The "Shale bed."
13	..	1	13	..	Upper eight feet soft shale underlain by a rather hard, massive, impure limestone layer about two feet thick. Underneath this the limestone is blue, mottled and interspersed with arenaceous material. The *Tetradium* reef forms the base of this division.

Height of the falls 35 feet, by tape.

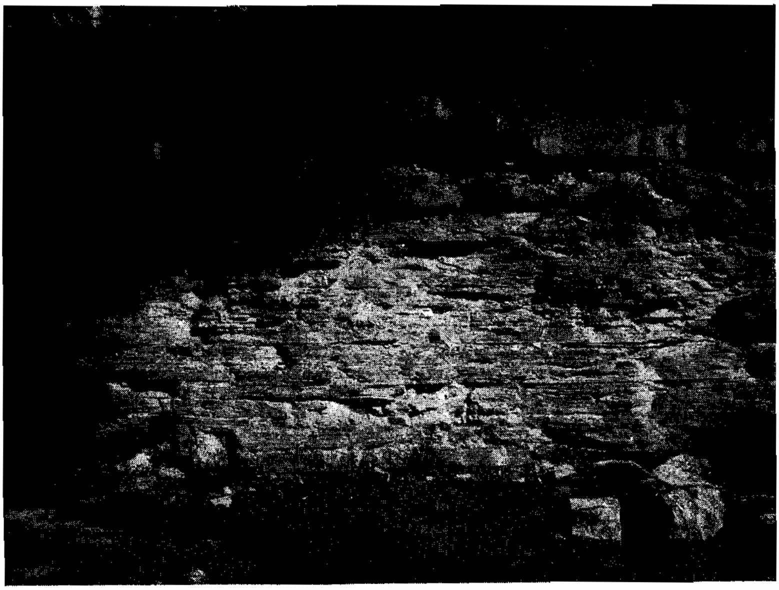

Fig. 4.—Shale bed on west fork of Cedar Creek, Versailles, upper massive layer at top of exposure *a*.

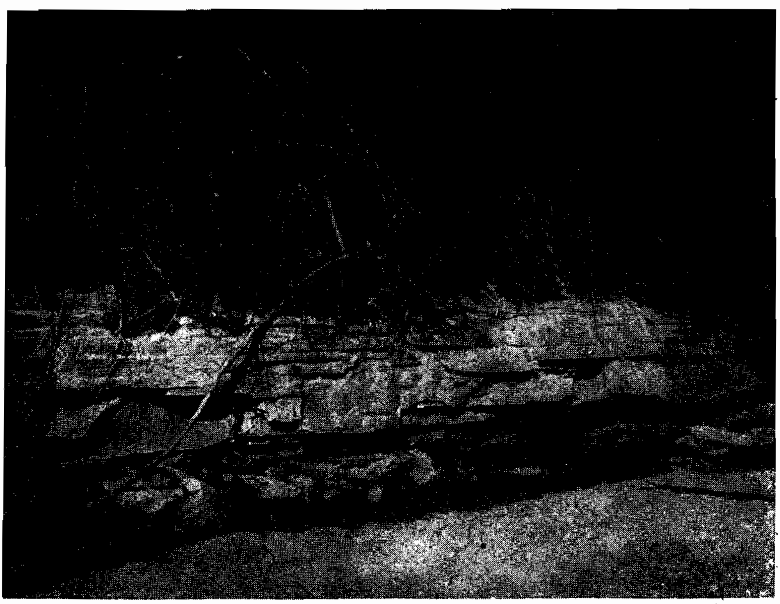

Fig. 5.—Base of shale bed at 1.59D. Here the base of the bed is becoming quite arenaceous.

Section Along the West Fork of Cedar Creek, Versailles, Indiana, from the Base of 80-Foot Cliff to the Point Where the Osgood-Versailles Pike Crosses the Creek. 1.60H.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
101	..	11	9	..	Uneven, thin-bedded, lumpy, yellow-weathering limestone. *Platystrophia acutilirata senex* (aa), *Monticulipora epidermata* (rr), *Homotrypella rustica* (c), *Homotrypa wortheni* (a).
92	..	10	5	..	At bottom of road metal quarry, near the pike, massive, hard limestone layer.
87	..	9	18	..	Coarse grained rather soft gray limestone in thick layers; thin-bedded in the top 4 feet. Mostly unfossiliferous, fossils small and obscure. Some layers contain Pelecypods rather commonly. This is the "*Mottled bed*" of this report.
69	..	8	4	..	Heavy, hard, fine-grained layers immediately overlying the "Shale bed." No fossils.
65	..	7	8	6	*Shale bed.* This bed consists of thin layers of rather hard, calcareous drab shale, conspicuously ripple-marked and sun-cracked. The layers vary in thickness from a fraction of an inch to several inches. The whole bed is conspicuously jointed, the joints (main system) running N. 73° E.
56	6	6a	2	..	Base of the shale bed, consisting of about 2 feet of very hard, barren limestone.
54	6	6	9	6	Dark-colored limestone containing *Tetradium* (aaa), especially at the base. Some of the individuals measure as much as 4 feet 7 inches in diameter.
45	..	5	8	..	Dark-colored, uneven limestone, Bryozoa (aaa). This is the *Bryozoa bed* of this report.
37	..	4	5	..	Limestone; not very fossiliferous; top a hard, thick layer.
32	..	3	7	..	Limestone in rather thick layers.
25	..	2	5	..	Exposure in bed of creek and also in the 80-foot cliff of the thick layers of limestone containing *Plectambonites sericeus* (aaa).
20	..	1	20	..	Lower 20 feet of the 80-foot cliff. Mostly limestone. *Platystrophia acutilirata, Rhynchotrema capax*, etc. Very fossiliferous.

Base of the section is the creek bed at the base of the 80-foot cliff. This cliff is one-half mile up stream from the junction of the north and south forks of Cedar creek, in the north bank of the creek.

The fauna of No. 11 is as follows: *Homotrypa wortheni* (*a*), *H. constellariformis, H.* cf. *austini, Homotrypella rustica* (*c*), *Mon-*

ticulipora epidermata, M. sp. (very similar to *M. mammulata*) *Bythopora meeki* (c), *Dekayia subramosa* (c), *Peronopora pavonia* var., *Rhombotrypa quadrata* (small ramose form with well developed monticules), *Callopora* sp. (sharp monticules similar to *C. ramosa*), *Ceramoporella ohioensis, Ptilodictya plumaria, Platystrophia acutilirata senex, P. acutilirata, P. laticosta, Hebertella occidentalis* (c), *H. sinuata, Rafinesquina alternata, Zygospira modesta, Streptelasma divaricans* (c), *S. rusticum* (r), *Protarea vetusta, Byssonychia richmondensis, B.* sp. (may be *B. suberecta*), *Ischyrodonta elongata, Opisthoptera casei, Protowarthia subcompressa, Schizolopha moorei, Lophospira tropidophora, Lophospira* sp.

The fauna of No. 5 is as follows: *Hebertella occidentalis, Platystrophia laticosta* (large, very plump), *Strophomena* sp., *Rafinesquina alternata, Zygospira modesta, Dicranopora emacerata* (c), *Bythopora delicatula, B. meeki, Rhombotrypa quadrata* (aaa), *Monticulipora epidermata* (rr), *Dekayia subramosa* (c), *Callopora subnodosa, Arthropora shafferi, Rhinidictya* sp. (c), *Homotrypa* cf. *austini, Homotrypa* sp. (frondescent with well-developed monticules), *Homotrypa* sp. (frondescent, smooth), *Calapoecia cribriformis* (r), *Streptelasma rusticum, Protarea vetusta* (r), *Stromatopora* sp., *Isotelus maximus, Pterinea demissa, Lophospira* cf. *ampla.*

Section of the High Wash Bank on the West Fork of Cedar Creek, Just Above the Junction with the North Fork. 1.601.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
60	..	2	40	..	Highly fossiliferous limestone and shale. *Rhynchotrema capax, Strophomena planumbona, Hebertella occidentalis, protarea vetusta Streptelasma rusticum, Batostoma varians, Bythopora meeki, Leptaena rhomboidalis* (a). *Platystrophia laticosta* (abundant in the lower five feet), *Rhombotrypa quadrata.*
20	..	1	20	..	Shale and limestone. *Dalmanella meeki* is the characteristic fossil. To creek level.

This exposure is not adapted to the making of a detailed section on account of the amount of talus on the surface of the exposure.

Section Along the North Fork of Cedar Creek, Just North of Versailles. 1.60G.

86	..	13	5	..	Fairly thick layers of limestone. *Plectambonites sericeus* (aaa). Base of the Liberty beds.
81	..	12	20	..	Covered.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
61	..	11	4	..	Thin limestone layers with shale partings. Bryozoa (aaa).
57	..	10	5	..	Covered.
52	..	9	2	..	Limestone. *Leptaena rhomboidalis, Platystrophia laticosta, Batostoma varians, Dekayia prolifica*, etc.
50	..	8	5	..	Covered.
45	..	7	1	..	Shale and limestone. *Dalmanella meeki, Platystrophia laticosta.*
44	..	6	10	..	Covered.
34	..	5	2	..	*Dalmanella meeki, Plestambonites sericeus, Leptaena rhomboidalis*, etc.
32	..	4	4	..	Thin limestone and shale. *Dalmanella meeki* (aaa).
28	..	3	10	..	Covered.
18	..	2	3	..	Several thin layers of limestone separated by bands of soft blue shale. *Dalmanella meeki* (aaa).
15	..	1	15	..	Covered to the level of Laughery creek at the mouth of Cedar creek.

Section on a Small Western Tributary of Laughery Creek, Two Miles Northeast of Osgood. 1.61A.

75	..	8	15	..	Top = base of the *Clinton*. Nearly all covered. Several compact layers exposed near the top in contact with the overlying Clinton.
60	..	7	5	..	Exposed at 1.61C near the Clinton contact shown at No. 8 of this section. Nodular limestone and shale containing numerous fossils. *Platystrophia laticosta, P. lynx, Hebertella occidentalis, Strophomena sulcata, Strophomena neglecta, Streptelasma divaricans, Protarea vetusta, Rhombotrypa quadrata, Homotrypa wortheni, Peronopora pavonia.*
55	..	6	25	..	Partly covered. The exposed portions like No. 7.
30	..	5	7	..	Soft, gray, mottled limestone. Few fossils.
23	..	4	11	..	Soft, gray, mottled limestones like No. 5. The top of this zone is formed by a layer in which *Tetradium* is very abundant. Upper reef.
12	..	3	10	..	Ripple-marked and sun-cracked gray, slabby shale. The *Shale Bed*. The upper part is formed by a strong, massive layer. *Perfectly typical.*
2	..	2	2	..	Massive layer of limestone. Forms the base of the shale bed.
..	..	1	..	..	Several feet of limestone containing *Tetradium* in abundance. This is the *lower Tetradium reef.*

Section on the West Branch of Laughery Creek, Four Miles Southwest of Batesville. 1.62D.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
49	..	9	6+	..	Shaly, nodular limestone. Fossiliferous.
43	..	8	..	8	Hard, thin layers of limestone.
42	5	7	5	10	Shaly limestone. Same as No. 9.
36	7	6	1	3	Thicker layers of limestone.
35	4	5	17	6	Soft limestone and shale. "Mottled bed."
17	10	4	4	8	Hard, massive limestone overlying the "Shale bed." Light blue.
13	2	3	6	8	Ripple-marked and sun-cracked, slabby shale. The "Shale bed."
6	6	2	1	..	Massive, drab, barren limestone, somewhat shaly in the upper part. The massive layer underlying the shale bed.
5	6	1	5	6	Somewhat arenaceous, much jointed shale, inclined to be massive in the lower part.

The base of the section is creek level.

Section on the West Branch of Laughery Creek, Four Miles Southwest of Batesville. 1.62F.

63	3	9	40	..	Covered to the top of the hill.
23	3	8	1	..	Shale like that of No. 6.
22	3	7	0	8	Compact limestone layer.
21	7	6	5	..	Ripple-marked and sun-cracked, slabby shale. Nos. 6, 7 and 8 constitute the "Shale bed."
16	7	5	1	..	Massive layer at base of Shale bed.
15	7	4	10	10	Light colored, uneven limestone layers, varying in thickness from 1 foot to 10 feet, with intercalated soft, dark colored shale. Some layers contain a few specimens of *Tetradium*. The upper few inches is a black, fine shale.
4	9	3	1	3	Massive gray limestone, with pockets of calcite and good specimens of *Tetradium*.
3	6	2	2	..	Shaly limestone and blue shale.
1	6	1	1	6	From water level to top of a layer containing *Columnaria alveolata*.

Base of the section is the level of the creek.

Section One and One-Half Miles Northwest of Oldenburg. 1.63D.

81	..	4	70	..	Covered to top of hill.
11	..	3	3	..	Massive, hard, gray, barren limestone layer.
8	..	2	7	..	Ripple-marked and sun-cracked, slabby shale. "Shale bed."
1	..	1	1	..	Massive layer below the shale bed.

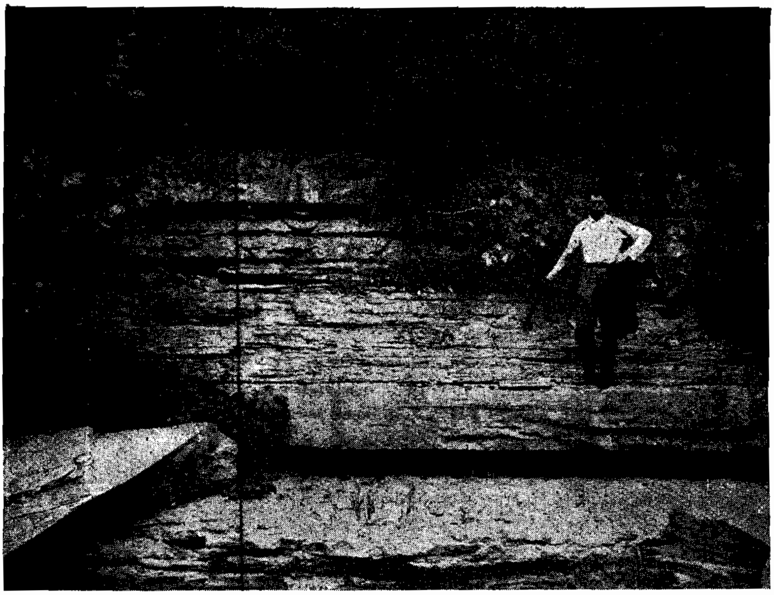

Fig. 6.—Shale bed at 1.64B. The man is standing on the lower massive limestone layer *a*, with his head opposite the upper massive layer *b*.

Fig. 7.—"Massive (limestone) bed" at the quarries 1½ miles south of Main street, Richmond (1.41D).

Section on Big Salt Creek, Four Miles West of Oldenburg. 1.63E.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
107	..	4	60	..	Mostly covered to the top of the hill. Base a massive bed of limestone a few feet in thickness.
47	..	3	4+	..	"Shale bed;" perfectly typical, but thinner than usual.
43	..	2	1	..	Massive, barren, gray limestone layer.
42	..	1	42	..	Well-defined limestone layers from 1 inch to 6 inches in thickness. The upper ten feet contains *Tetradium*. *Plectambonites sericeus* occurs in abundance a few feet above the level of the creek at the base of the section.

Section on the North Fork of Big Salt Creek, Two Miles West of Hamburg. 1.64B.

120	..	10	11	..	Pink, coarse-grained, crystalline, massive limestone. *Clinton.*
109	..	9	40	..	Partly covered. The top layers consist of gray, shaly limestone containing *Platystrophia laticosta*, *P. lynx*, *Rhynchotrema capax*, *Hebertella occidentalis*, *Strophomena sulcata*, *Homotrypa wortheni*, *Streptelasma divaricans*. Some of the layers present very much the same lithological appearance as the upper beds containing *Platystrophia lynx* on Elkhorn creek, south of Richmond. The layers exposed at the base of this division at creek level contain *Rhynchotrema dentata* (abundant in one layer), *Strophomena sulcata*, *Monticulipora epidermata*, *Rhombotrypa quadrata*, *Peronopora pavonia*, *Platystrophia acutilirata-senex*, *P. laticosta*, *Batostoma varians*, *Streptelasma rusticum*, *Streptelasma divaricans*, etc.
69	..	8	15	..	At the base of this division *Tetradium* occurs abundantly, about 9 feet below a bed of shale that resembles to some extent the true "shale bed," but entirely lacks its associated beds.
54	..	7	20	..	Limestone and shale.
34	2	6	1	10	Very hard, gray, barren limestone. Upper massive bed.
32	4	5	3	4	Drab to gray limestone with intercalated soft shale. Probably this is the calcareous representative of the upper part of the Shale bed.
29	..	4	2	2	Typical sun-cracked and ripple-marked, slabby, drab shale. The "Shale bed."

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
26	9	3	1	9	Very hard, calcareous layer. When considerably weathered it splits up into thinner plates that resemble the layers of the shale bed.
25	..	2	4	..	Light colored, nodular, arenaceous limestone, separated from the overlying, massive layer by a thin bed of black, gritless, carbonaceous shale. At the base of this zone is a layer containing *Tetradium* in abundance.
21	..	1	21	..	Limestone with intercalated shale exposed in the bed of the creek for half a mile down stream from the locality of No. 2, and containing the characteristic fauna of the Liberty beds.

Section Along the Western Branch of Big Salt Creek, Three Miles North of Hamburg. 1.64D.

117	..	22	10	..	Hard, brownish layers of nearly barren limestone. Top in contact with the *Clinton*.
107	..	21	5	..	Blue limestone and shale.
102	..	20-19	5	..	Limestone and shale. The upper layer (No. 20) contains bryozoa very abundantly.
97	..	18	10	..	Covered.
87	5	17	0	5	Rough, hard layer of limestone.
87	..	16	13	..	Covered except at the top, which consists of soft, blue shale.
74	..	15	0	4	Irregularly jointed and cracked layer of limestone.
73	6	14	2	..	Limestone.
71	6	13	3	..	Slabby, brown to drab, sun-cracked shale.
68	6	12	6	..	Blocky, blue, much jointed, arenaceous shale. The main joints are only a few inches apart and run S. 20° W.
62	6	11	0	6	One layer of barren, arenaceous limestone.
62	..	10	1	..	Shale.
61	..	9-8	5	..	Blue mottled, coarse-grained, fossiliferous limestone. The top a hard layer containing *Streptelasma rusticum* in abundance.
56	..	7-6	15	..	Partly covered. Limestone and shale, containing *Tetradium* at the top (No. 7).
41	..	5	1	..	Hard, barren, blue, fine-grained limestone.
40	..	4	4+	..	Shaly, somewhat calcareous bed.
35	6	3	1	..	Hard, bluish gray, coarse-grained, fossiliferous limestone. Contains *Tetradium*.
34	6	2	34	..	Mostly fossiliferous limestones with intercalated soft, blue shale. Some of the limestone layers are fine-grained, hard and barren. Typical Liberty fauna.
0	6	1	0	6	Wave-marked, hard layer of limestone with *Plectambonites sericeus* abundant.

Section in a Gully Entering Big Sains Creek from the Northeast, Two and One-Quarter Miles Northwest of Laurel. 1.14F. (No. 235 of Foerste's Paper.)

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
91	..	18	5	..	Pink, coarse-grained limestone. *Clinton.* Overlain by the light-colored, hard limestones of the Niagara formation.
86	..	17	15	..	Mostly strong layers of rather barren limestone with some intercalated gray shale.
71	..	16	8	..	Brownish to yellowish, blue-mottled bed of arenaceous, soft limestone. *Platystrophia* and *Hebertella* common at the base.
63	..	15	7	..	Soft, gray, somewhat arenaceous shale, blocky and much jointed.
56	..	14	5	..	Three to five feet of overhanging layers of limestone.
51	..	13	10	..	Mostly soft, gray, blocky, somewhat arenaceous shale. Some limestone layers contain *Platystrophia acutilirata-senex* and *Hebertella occidentalis*, and numerous bryozoa.
41	..	12	10	..	Mostly like No. 13.
31	..	11-10	5	..	Combined thickness of Nos. 10 and 11 is 5 feet. Upper part a massive, hard limestone with *Tetradium* at the top. Lower part soft, gray, arenaceous shale. This is probably the upper *Tetradium reef.*
26	..	9	2+	..	Thick ledge of limestone.
24	6	8	2	..	Heavy layer, weathering into thin, conspicuously overhanging layers. Limestone.
22	6	7	3	..	Hard, nodular layers, projecting still more than those above.
19	6	6	1	6	Softer shale and limestone. Shale dark and somewhat carbonaceous.
18	..	5	1	..	Harder and somewhat arenaceous limestone.
17	..	4	2	..	*Tetradium* large and abundant.
15	..	3	3+	..	Limestone projecting in breast of lower waterfall. Underlain by very soft shale.
12	..	2-1	12	..	Shale and limestone with some thick ledges to level of Sains creek.

Section on Big Sains Creek One-Quarter Mile Up Stream from 1.14F. 1.14G.

27	..	6	15	..	Soft, nodular limestone and shale. *Rhynchotrema dentata* occurs at the top.
12	..	5	1+	..	Rather massive limestone layer.
10	8	4	3	..	Uneven, rather arenaceous shale and limestone.
7	8	3	2	..	Massive layer of limestone.
5	8	2	5	..	Limestone layers from two inches to 8 inches thick, with dark, somewhat carbonaceous shale partings.
0	8	1	0	8	Black, gritless, carbonaceous shale.

Section Along the Headwaters of Little Duck Creek, Three Miles Northwest of Blooming Grove, Franklin County. 1.65A.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
56	..	4	1	..	Hard, thick layer of limestone.
55	..	3	4	..	Partly covered, uneven layers of limestone.
51	..	2	1	..	Hard, thick layer of limestone. Contains *Tetradium.*
50	..	1	50	..	Partly covered limestone and shale, with the typical Liberty fauna. Base a layer containing *Plectambonites sericeus* in abundance.

Section Along a Small Tributary of Whitewater River, Two and a Half Miles Southeast of Quakertown, Union County, Indiana. 1.66A.

95	..	3	15	..	No rock exposed to top of hill.
80	..	2	35	..	Very little exposed rock except at the top, where, in about three feet of soft, nodular shale, the following species were found: *Streptelasma divaricans, S. rusticum, Rhynchotrema capax, Strophomena sulcata, Platystrophia acutilirata, P. laticosta, Protarea vetusta, Ptilodictya plumaria, Homotrypa flabellaris, Rhombotrypa quadrata.* At the base of this division *Tetradium* occurs in great numbers, loose, but evidently not far out of place.
45	..	1	45	..	Nearly all well exposed limestone with shale partings. At the base *Plectambonites sericeus* occurs in abundance.

Section at the Quarry and Along the Small Tributary of Silver Creek, One Mile West of the Center of Liberty, Indiana. 1.67A.

68	..	6	40	..	Nearly all exposed, limestone with shale partings. The top of this division is formed by a thick layer containing *Tetradium* in abundance.
28	..	5	10	..	Rather even, hard layers of limestone exposed in the quarry.
18	..	4	2	..	Limestone containing *Plectambonites sericeus* in abundance. Exposed in the creek just across the road from the quarry.
16	..	3	1	..	To level of the base of the quarry. At this level in the creek *Plectambonites* is very abundant.
15	..	2	10	..	Thin layers of limestone with intercalated beds of soft, blue shale. *Plectambonites* occurs at the base of this division in a wave-marked layer.
5	..	1	5	..	To the level of Silver creek.

Section Along Small Eastern Tributary of Whitewater River, One and One-Half Miles South of Abington, Wayne County. 1.41B.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
26	..	3	15	..	Shale and thin limestones, mostly loose pieces. *Rhynchotrema capax, Hebertella insculpta, Strophomena planumbona,* etc.
11	..	2	5	6	Shale and thin limestones. *Platystrophia laticosta, Strophomena planumbona, Dalmanella meeki, Batostoma varians,* etc.
5	6	1	5	6	Shale and thin limestones. *Dalmanella meeki, Platystrophia laticosta, Batostoma varians, Homotrypa flabellaris,* etc.

Section of Elkhorn Creek, Four Miles South of Richmond. 1.41A.
(Section measured in 1907.)

180	..	18	10+	..	*Clinton* at Elkhorn Falls. Ten to twelve feet thick at the falls. Probably somewhat thicker farther up stream.
170	..	17	4	..	Very soft shale, weathering rapidly to a clay. It is the presence of this shale bed that causes the Clinton ledge to overhang so conspicuously at the falls and along the upper end of the gorge. No. *1* of 1901 section.
166	..	16	6	..	Hard, brownish to greenish, coarse-grained, fairly even layers of limestone seen at creek level just below the mill and at the top of the 30-foot cliff in the north side of the gorge about one mile down stream from the falls. Contain *Platystrophia lynx-moritura* (*aa*), *Hebertella sinuata* (*a*) and *Homotrypa wortheni* (*c*). No. *2* and *10b* of 1901 section.
160	..	15a	25	..	Blocky, shaly, somewhat arenaceous limestone; fairly massive at the bottom and more shaly at the top. Fauna much the same as that of No. 16. No. *10a* of 1901 section.
135	..	15	1	..	Strong, granular, reddish layer. Fossils mostly small and poorly preserved.
134	..	14	5	..	Soft, blue, unfossiliferous shale exposed at the base of the 30-foot cliff, one mile below the falls.
129	..	13	10	..	Soft, blue shale with a few thin limestone layers exposed in the south bank of the creek about one-half mile farther down stream. No. *9* of 1901 section.
119	..	12	20	..	Some heavy, hard layers; mostly covered. These layers contain *Rhynchotrema dentata* at the base.
99	..	11	10	..	Mostly covered.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
89	..	10	5	..	Nodular limestone with *Rhynchotrema dentata* (*aa*) exposed along the creek in the open pasture just west of the road that runs straight south from Richmond. No. *8* of 1901 section.
84	..	9	15	..	Uneven, nodular, shaly, blue, highly fossiliferous limestone exposed in a long, low cliff in the east bank of the creek about one-half mile down stream from No. 10. *Rhynchotrema dentata* occurs at the top of the exposure. At the base occurs the form of *Platystrophia acutilirata* with very long cardinal angles. *Streptelasma rusticum* (*aa*) very large. No. *7* of 1901 section.
69	..	8	3+	..	Same as No. 9. This is the interval between the top of the exposure at the spring and the exposure of No. 9.
66	..	7	25	..	At the spring near the crossing of the east-and-west road in Section 29, long cliff exposure of nodular, very fossiliferous limestone and shale. *Rhynchotrema capax* (*aaa*), *Monticulipora epidermata* (*a*), *Rhynchotrema dentata* (*r*). No. *6* of 1901 section.
41	..	6	0	14+	Hard, strong, rather coarse-grained layer of limestone seen at creek level in No. 7, and in both banks of the creek for some distance down stream. It contains numerous pockets of calcite and an occasional small specimen of *Tetradium*.
40	..	5	10	..	Layers of limestone from two inches to 8 inches thick, with intercalated shale. *Rhynchotrema capax* large and abundant. *Platystrophia laticosta, Strophomena neglecta.*
30	..	4	10	..	Covered.
20	..	3	10	..	Mostly fairly even layers of limestone. Exposed in the south bank of the creek about a quarter of a mile east of the crossing of the Liberty pike. No. *5* of 1901 section.
10	..	2	9	..	About 200 feet up stream from the Liberty pike bridge. Mostly limestone (with shale partings). *Dinorthis subquadrata, Hebertella insculpta, Strophomena planumbona.*
1	..	1	1	..	Thick limestone layers exposed at creek level just above the Liberty pike bridge. *Plectambonites sericeus* (*aa*) occurs at creek level. No. *4* of 1901 section.

The base of this section is about 50 feet above the level of the Whitewater river at the mouth of Elkhorn creek. Occasional ex-

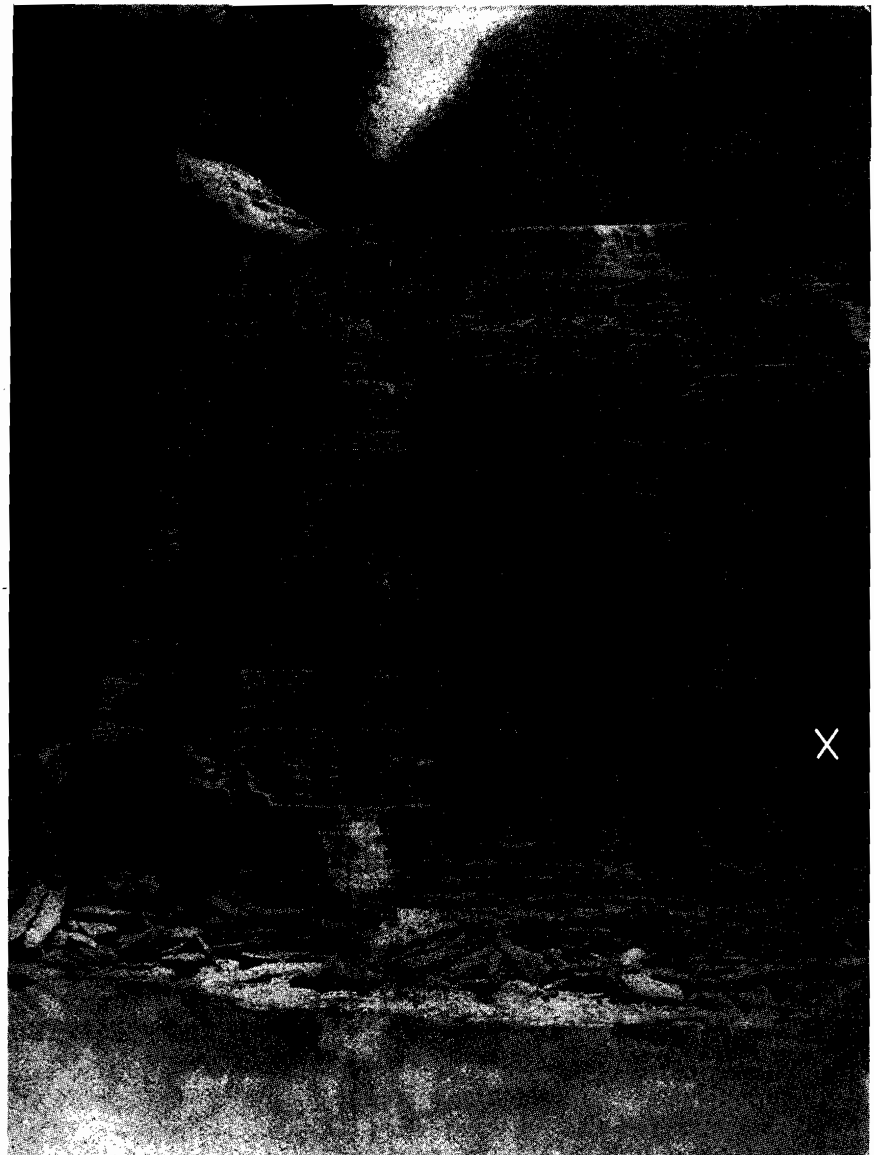

Fig. 8.—View of the cliff below the sewer at the west end of South G street, Richmond. This exposure shows the entire thickness of the Liberty beds. The *Plectambonites* layer is at X.

posures of rock occur throughout some 30 feet of this distance. *Plectambonites* occurs 25 feet below the base of this section.

Section on Small Western Tributary of Whitewater River, Four Miles Southwest of the Main Street Bridge, at Richmond. 1.41C.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
23	..	1	16	..	Very fossiliferous thin limestone and shale. *Plectambonites sericeus* (aaa), *Strophomena planumbona* (c), *Rhynchotrema capax* (c), *Strophomena neglecta, Dinorthis subquadrata, Platystrophia acutilirata* (r), *Rhombotrypa quadrata, Callopora subnodosa*, etc.
7	..	2	5	..	Limestone layers in creek bed just below No. 1. *Dinorthis subquadrata* (c), *Strophomena planumbona* (a), *Plectambonites sericeus* (rc), *Hebertella insculpta* (rr), *Crania laelia, Fenestella* sp., *Rhopalonaria venosa*, etc.
2	..	3	2	..	Limestone and shale. Same fauna as No. 2.

Section at the Quarries Just South of the Steel Highway Bridge, One and One-Half Miles South of the National Road, Richmond, and Along the River from the Bridge to the National Road. 1.41D.

No. 2 of this section is the basal member of the section.

40	..	1	20	..	Quarries just south of the steel bridge, one mile south of the National road. Thin limestones and shale, with thicker beds at the top. *Rhynchotrema capax* (aaa), *Dinorthis subquadrata* (a), *Constellaria limitaris*, and *C. polystomella.*
20	..	2	20	..	Exposure in the east bank of the river at the mouth of a sewer nearly three-quarters of a mile south of the National road. The *Plectambonites sericeus* layer is here six feet above river level. This is the lowest exposure of the Richmond beds in the immediate vicinity of Richmond.

The fauna of 1.41D1 is as follows: *Dinorthis subquadrata* (a), *Rafinesquina alternata* (c), *Rhynchotrema capax* (aaa), *Zygospira modesta* (c), *Platystrophia acutilirata* (c), *Hebertella occidentalis* (rc), *Strophomena neglecta* (c), *S. planumbona* (c), *Streptelasma rusticum* (r), *S. divaricans* (rc), *Protarea vetusta* (c), *Dicranopora emacerata* (c), *Arthropora shafferi* (c), *Bythopora striata* (c), *B. delicatula* (rc), *B. meeki* (rc), *Batostoma varians* (rr), *Rhombotrypa quadrata* (aa), *Prasopora hospitalis* (rc), *Callopora subnodosa* (a), *Constellaria limitaris* (r), *C. poly-*

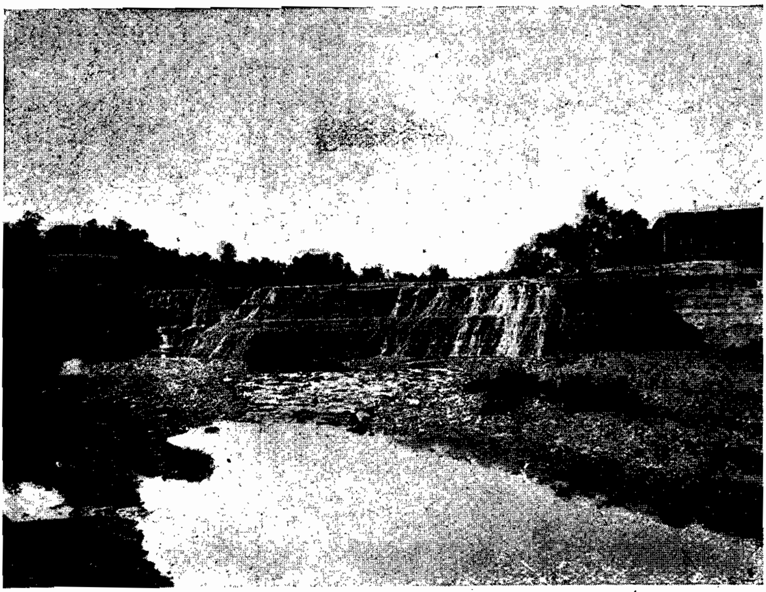

Fig. 9.—Thistlewaite Falls on West Fork, Richmond. *Rhynchotrema dentata* beds.

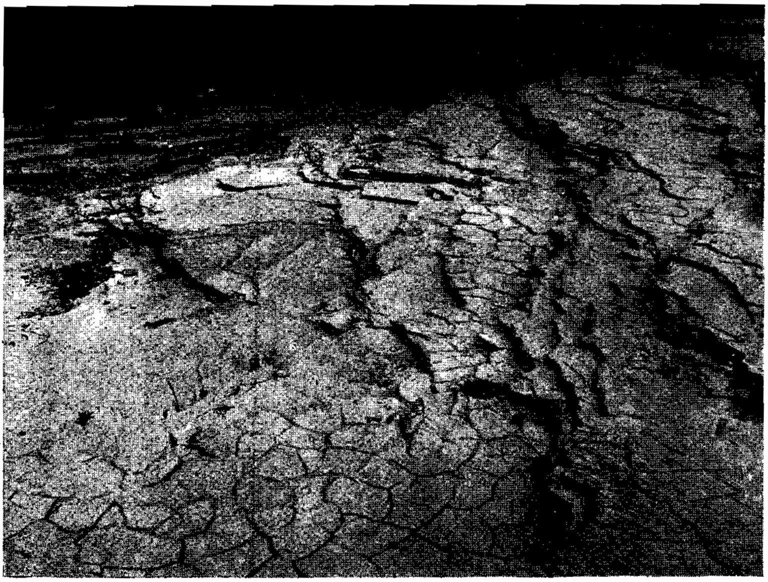

Fig. 10.—Sun-cracks in the "Shale Bed," on west fork of Cedar Creek, Versailles.

stomella, Homotrypella rustica (r), *Homotrypa flabellaris* (r), *H.* cf. *austini* (c), *Amplexopora* sp., *Ceramoporella ohioensis* (rr), *Proboscina frondosa, Calymmene callicephala* (rr), *Orthoceras* sp., *Pterinea demissa, Cyclonema* sp., *Byssonychia* sp., *Cornulites* sp. and several sp. of Ostracoda and Crinoids. This is the typical Liberty fauna.

The fauna of 1.41D2 is the same, with the addition of *Plectambonites sericeus* (aaa), *Strophomena subtenta, Fenestella* sp., *Helopora elegans,* and *Anomalodonta gigantea.*

Section Along the West Fork of Whitewater River at Richmond, Indiana. 1.41E.

In this section No. 1 is at the top of the section and No. 7 at the base.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
41	8	1	8	..	Exposures in the bank above Thistlewaite falls, on the west fork of Whitewater river, about one and one-quarter miles north of the National road bridge across Whitewater river. Thin, lumpy limestone. *Rhynchotrema dentata* (aa). Several species of Gastropods, including *Salpingostoma richmondense* (c), *Strophomena sulcata* (r).
33	8	2	10	..	Layers in the breast of the falls. Heavier layers at the top. Limestone. *Monticulipora epidermata* (c), *Platystrophia acutilirata* var., *senex* (c), *Homotrypa wortheni.*
23	8	3	5	..	West side of creek just below the falls. Bryozoa (aaa), *Monticulipora epidermata,* etc.
18	8	4	5	..	Just north of C., R. & M. R. R. bridge. Thin, shaly limestone. *Rhynchotrema capax,* highest specimens. *Plectambonites sericeus* (rr).
13	8	5	4	8	Just south of C., R. & M. R. R. bridge. *Rhynchotrema capax* (aa).
9	..	6	5	..	About one-eighth mile north of the road bridge across the west fork. *Ptilodictya plumaria,* etc.
4	..	7	4	..	A short distance north of the junction of the east and west forks of the river. Limestone and intercalated shale. *Callopora* very similar to *C. rugosa.* *No* specimens of *Rhynchotrema dentata.*

For the faunas of this section see the species chart.

Section Along the Whitewater River at Richmond, Indiana. 1.41D,E.

General Section.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
107	..	13	11	..	Same as No. 12. Contains *Rhynchotrema dentata*.
96	..	12	18	..	Nodular limestone and shale. Many of the layers are several inches thick and fairly continuous. *Rhynchotrema dentata* (*a*). These beds are seen along the top of the gorge from the National road to Thistlewaite falls, on the west fork of the river, about a mile northwest of Richmond. They form the falls and the exposures in the bank of the creek above the falls.
78	..	11	20	..	Soft, nodular limestone and shale exposed along the gorge from the quarries one mile south of Richmond to the falls. *Rhynchotrema dentata* occurs sparingly in the upper part of this zone. The characteristic fossils are: *Rhynchotrema capax* (except in the upper part), *Platystrophia acutilirata, Hebertella occidentalis, Monticulipora epidermata, Homotrypella rustica, Ptilodictya plumaria, Salpingostoma richmondensis*.
58	..	10	5	..	Same as No. 11. Forms the top layers of the quarries on the east side of the river one mile south of Richmond (at the steel bridge). Base of the so-called Whitewater division.
53	..	9	0	5	Firm, hard layer of limestone. This and the five divisions below are best seen at the quarries in the east bank of the river just south of the steel bridge, one mile south of Richmond.
52	5	8	1	..	Thick layer of hard limestone, separated from No. 9 by a parting of shale.
51	5	7	1	2	Shale and thin limestone.
50	3	6	2	3	Massive limestone layer that is sometimes seen in well weathered exposures to split into several thinner layers. Coarse grained and with occasional pockets of Calcite crystals. Fossils do not readily weather out.
48	..	5	0	5	Dark, soft, gritless shale, apparently somewhat carbonaceous.
47	6	4	1	..	Fairly firm layer of limestone that is seen on weathering to split into several layers. Nos. 4 to 9 probably represent the interval of the *shale bed* in the sections farther south, or the massive limestone layers associated with it.

Total Thickness.		No.	Thickness of Bed.		
Ft.	In.		Ft.	In.	
46	6	3	40	..	Fairly even, compact layers of limestone from an inch or less to six or eight inches in thickness, with beds of intercalated shale. Some of the limestone layers are quite fine grained and barren, while others, especially toward the base, are coarser grained and very highly fossiliferous. Typical Liberty fauna. *Dinorthis subquadrata*, *Rhynchotrema capax* and *Strophomena planumbona* are the common brachiopods. *Plectambonites sericeus* occurs at the base. LIBERTY FORMATION.
6	6	2	0	6+	Strong layer of limestone containing *Plectambonites sericeus* in such abundance as to completely fill the top of the layer.
"	..	1	6	..	Very fossiliferous limestone with shale partings. *Plectambonites sericeus*, *Hebertella insculpta* and *Strophomena planumbona* are the common fossils. River level.

Nos. 1 and 2 are best exposed at the mouth of a sewer near the slaughter houses in the south edge of Richmond. No. 3 is also beautifully exposed here and along the gorge to the National road. No beds lower than the base of this section are shown in the near vicinity of Richmond.

DISCUSSION OF THE STRATIGRAPHY.

It has been seen that prior to the work of Messrs. Ulrich, Nickles and Foerste, and the writer, practically nothing definite was known regarding the detailed stratigraphy of the rocks of the Cincinnati series. In 1900 the writer published a portion of his field notes of that season and drew certain conclusions as to the faunal zones into which he proposed to divide this series of formations. These were as follows in the ascending order: *Dalmanella multisecta* zone, *Rafinesquina alternata* zone (or lower *Rafinesquina* zone), *Platystrophia* zone, *Rafinesquina fracta* zone, *Dalmanella meeki* zone, *Streptelasma* zone, *Strophomena* zone, and *Rhynchotrema capax* zone. Of these zones the further progress of the work has resulted in the definite retention of the first, third, fourth, fifth and seventh. The lower *rafinesquina* zone is a well characterized zone, as can readily be seen from a study of the faunas. It is perhaps better characterized by the abundance of *Callopora dalei* than of any other species. It is in part the Mount Hope or *Amplexopora septosa* beds of Nickles. I have found, however, that the *Platystrophia laticosta* comes in sparingly well down in this zone, and that on the lithological side it is characterized by a predomi-

Fig. 11.—Cut No. I, Tanner's Creek. Just south of Guilford station. Upper Eden shales.

Fig. 12.—Cut No. II, just north of Guilford. Upper Eden shales. Base of Lorraine at top of cut.

nance of limestone, although the shale element is greater than in the next zone. It has seemed best, therefore, to begin the *Platystrophia* zone with the setting in of the limestones and the small form of *P. laticosta*. This carries the base of the *Platystrophia* zone somewhat lower than in my former paper, and eliminates the lower *Rafinesquina* zone. The *Streptelasma* zone is not feasible, inasmuch it is now evident that this species (*S. rusticum*) is not restricted to any well characterized zone but is found in both the Liberty and Whitewater beds. The *Strophomena* (*planumbona*) zone is extended in harmony with the ideas of Nickles and Foerste to include all of the Liberty formation; and the *Rhynchotrema capax* zone gives way for reasons similar to those that apply in the case of the *Streptelasma* zone. *Rhynchotrema capax* zone might, however, be retained as a general designation of the Liberty and Whitewater divisions of the Richmond formation, to which this species is practically restricted.

Of the names that are retained in this report: The *Dalmanella multisecta* zone is a well marked and compact division, both lithologically and faunally. As will be seen from the sections 5.9A, 1.34C and 1.38A, this is the zone of predominant shale (the Utica or Eden shale of this and other reports). It is about 240 feet thick in Indiana. Nickles, as we have seen, has subdivided this zone on faunal grounds into three divisions, which he called the lower, middle and upper Utica, characterized by bryozoa, and these divisions have now received formation names (Economy, Southgate, McMicken). My study of the faunas of the lower division is not complete enough to warrant me in discussing the reality of this faunal division. The upper division is very well characterized, as long ago pointed out by Ulrich, by the great abundance of *Dekayia ulrichi*, and may well be called the *Dekayia ulrichi* zone. It is from 50 to 70 feet thick. Limestone layers are rather more numerous in this zone than in the lower portions of the *Dalmanella multisecta* zone, and the shale is somewhat lighter colored. The lithological facts are presented by the columnar sections drawn to scale, much better than is possible by description. (Sections 5.9A and 1.38A.)

The *Platystrophia* zone as the term is used in this report is the greater part of the Lorraine as it has generally been understood. It is about 100 feet thick, taking the base where the *Dalmanella multisecta* disappears and *Platystrophia laticosta* (small form) begins, and the top where the *Platystrophia lynx* and *P. laticosta* disappear. As I have remarked under the description of *P. lynx*, the gerontic (gibbous) form of that species that characterizes the

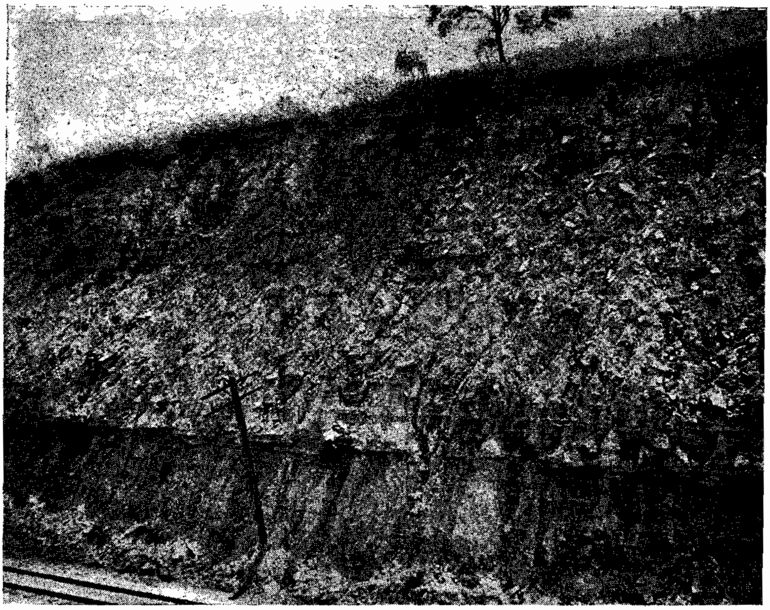

Fig. 13.—Cut No. V, Tanner's Creek. The man is standing at the base of the *Platistrophia* zone.

Fig. 14.—Cut No. VII, Tanner's Creek, showing the predominance of limestone in the typical Lorraine formation.

Mount Auburn beds of Nickles at Cincinnati and other places in Ohio is found very sparingly in Indiana, only an occasional specimen being see in a thin zone some 50 feet or more above the top of the *Platystrophia* zone, as the term is used in this report. That there is no bed of abundant specimens of this gerontic form of *P. lynx* in Indiana is a certainty. On Tanner's creek every inch of the Cincinnati series from the upper Eden shales to the top of the Liberty formation is now exposed in the railroad cuts, as can be seen from the profile published in the present report. Any such bed as caps the highest hills at Cincinnati could not possibly be overlooked. The normal form of *P. lynx* is present in considerable numbers in this section, though not by any means as abundant as in the Vevay section. At Madison and Clifty Creek, west of Madison, Indiana, the upper part of the *Platystrophia* zone is well exposed, and there is none but the normal, large form of the species. In section 1.12A every inch of the interval between the abundant occurrence of this normal form of *P. lynx* and the base of the *Dalmanella meeki* zone is exposed, and I have hunted the rocks with the greatest care without finding a single specimen of *P. lynx* in this interval. For Indiana, therefore, the gerontic *lynx* is not ordinarily available as a zone marker. The true top of the *Platystrophia* zone is where the normal *P. lynx* disappears. I may remark that on Straight Creek below Arnheim, Ohio, this horizon is some 60 or 80 feet below the point taken by Foerste as the base of the Arnheim division. It is true that in that section there is a thin bed of *Platystrophia lynx* at that elevation above what I should call the termination of the true *Platystrophia* zone (Bellevue beds). At the lower horizon on Straight Creek the *Platystrophia lynx* is present in immense numbers through a considerable thickness (50 feet) of rock; and is associated with *Hebertella sinuata,* as in the Indiana localities. This lower zone is, I am sure, the same as the zone of *Platystrophia lynx* at Vevay, Madison and elsewhere in Indiana. The *Platystrophia* zone is characterized lithologically by the predominance of limestone. In the lower part the layers are rather strong and hard, and have sometimes been quarried for foundations of houses, etc. The zone of these stronger limestone layers is the Hill Quarry beds of Orton. The upper part of the *Platystrophia* zone is characterized by thinner and more nodular limestone, especially where the *P. lynx* comes in abundantly. In the latter zone the rock is quite soft and shaly. This zone is capped by layers of hard, nearly barren limestone, in which the only common fossils are *Rafinesquina fracta* and *Cyclora minuta.*

The *Rafinesquina fracta* zone (upper *Rafinesquina* zone) or *Rafinesquina* zone, as I now propose to call it, is equivalent in part to the Arnheim formation. It is characterized throughout by the great abundance of *Rafinesquina alternata* (several varieties), and at several levels by immense numbers of *Zygospira modesta.* This latter feature can perhaps be best seen in section 1.12A. Practically this entire zone, and no others, is exposed in cuts Nos. X and XI on Tanner's Creek. On Tanner's Creek this zone is about 110 feet thick. In the Madison section (1.12A) the same zone is about 134 feet thick. Lithologically the zone is characterized by the predominance of shale, although the limestone layers are more frequent than in the Eden formation. Occasional thick, strong layers are present. It is in this zone, about 30 feet below the top, that the peculiar *Dinorthis retrorsa* occurs. Faunally the zone is marked by the coming in, toward the top, of a number of species that are characteristic of the Richmond formation—for example *Batostoma varians, Homotrypa flabellaris, Dalmanella meeki* (rare). At the same time it has a goodly number of Lorraine species at the bottom. The upper 60 feet of this zone is the Arnheim of Foerste. The lower 50 feet falls in the Corryville and Mt. Auburn of Nickles. In Indiana, however, the zone of gerontic *Platystropia lynx* is, as pointed out above, practically lacking, and the rocks from the top of the *Platystrophia* zone (of this report) to the base of the Waynesville form a unit both faunally and lithologically. If a faunal designation of the lower 50 feet is desired it might be called the *Callopora rugosa* zone. In Ohio this portion is said to be characterized by *Chiloporella flabellata.* The upper part of the *Rafinesquina* zone (Arnheim) is said by Nickles to be characterized by *Homotrypa bassleri.* According to present usage the line between the Richmond and Lorraine will fall at about the middle of the *Rafinesquina* zone. In cut No. X, on Tanner's Creek, a layer 6 inches to 10 inches in thickness, containing occasional specimens of the gerontic *Platystrophia lynx,* occurs eight and one-half feet above the level of the tracks at the north end of the cut. This layer I have taken as the equivalent of the Mt. Auburn of the Cincinnati section, and as, therefore, marking the boundary between the Lorraine and Richmond.

The *Dalmanella meeki* zone is the Waynesville division of the Richmond formation. It is an exceedingly homogeneous zone both faunally and Lithologically. *Dalmanella meeki* (or *Dalmanella jugosa*) is present throughout the zone, often in prodigious numbers. Other common fossils are *Bythopora meeki, B. delicatula,* *Eridotrypa simulatrix* (in the upper part), *Tentaculites richmondensis, Leptaena rhomboidalis* (near the top). At about the middle of the zone *Calymmene callicephala* is very abundant. This species is also found rather commonly in most of the layers of the zone. *Platystrophia laticosta* comes in abundantly near the top of this zone. All of these facts are well exhibited on the chart of the Tanner's Creek and Richmond sections. The zone is all beautifully exposed in the cuts on the new line of the Big Four Railroad along Tanner's Creek. Cut No. XIII exposes nearly the entire zone, and no others. The base of the zone may be seen in the small cut No. XII, just south of No. XIII, and the top may be studied in cuts Nos. XIII, XIV, XV, and XVI. Lithologically the zone consists of shale, for the most part, and thin, soft limestone layers, which are nearly always highly fossiliferous. Often the shells of *Dalmanella meeki* are present in immense numbers in the shale just under or over a layer of limestone. In such situations thousands of specimens of all stages of growth can be obtained perfectly free from the matrix. The bryozoa also are frequently found preserved in the same manner in the calcareous shale layers, and can then be obtained in great numbers and in the highest state of perfection.

This zone is not exposed at Richmond, but the extreme top of it may be seen near the mouth of Elkhorn Creek, four miles south of Richmond, and again about Abington, seven miles southwest of Richmond. It is well exposed along the north fork of Cedar Creek north of Versailles (1.60G), though here the base is not shown. In the high wash bank at the junction of the north and west forks of Cedar Creek (1.60I) the top of the zone is exposed, overlain by the base of the *Strophomena* zone. In the south cut at Madison, Indiana (1.12E), the lower part of the zone is exposed near the top of the cut. Here the zone is considerably thinner than in the Tanner's Creek section, namely, about 56 feet thick. It is extremely well exposed on Whitaker's Branch, along the line of the B. & O. S. W. R. R., between Cold Springs and Moore's Hill. In Ohio, the best localities are about Oregonia, Lebanon, and Oxford.

The *Strophomena* or *Strophomena planumbona* zone, as it may perhaps with greater propriety be called, is not as definitely characterized by that fossil as the zone just described is by the *Dalmanella meeki*. Several other species are present in equal or even greater strength; for example *Rhynchotrema capax, Bythopora meeki,* and *Rhombotrypa quadrata.* These latter species are not, however, restricted to the zone. The base of this zone is characterized by the presence of a number of brachiopods in enormous numbers. These are *Hebertella insculpta, Plectambonites sericeus, Leptaena rhomboidalis* and *Platystrophia laticosta,* the two last barely overlapping from the zone below. *Hebertella insculpta* is confined to about fifteen feet of rock and is abundant in only about the middle five feet of this. The first appearance of this species is taken by Foerste to mark the base of his Liberty formation. As will be seen from the chart of the Tanner's Creek section, this level is separated by only five feet from the horizon of the highest specimens of *Dalmanella meeki.* The *Strophomena planumbona* comes in exactly where *Damanella* leaves off, and *Rhynchotrema capax* comes in in the same layers with *Hebertella insculpta. Plectambonites sericeus* comes in in immense numbers in a wave-marked layer, about 18 feet above the top of the *Dalmanella meeki* zone (in the Tanner's Creek section). The occurrence of this species is perhaps more interesting than that of any others of the species in the zone. This species is not uncommon in the lower part of the *Dalmanella multisecta* zone. It is totally absent from the *Platystrophia* and *Rafinesquina* zones, and only a few specimens have been found in the *Dalmanella meeki* zone. It also occurs only very sparingly above the base of the *Strophomena planumbona* zone. An occasional specimen is seen in the Whitewater division. In the base of the *Strophomena* zone, however, the species is common through about fifteen feet of rock, and extremely abundant in several (sometimes only one) layers. It usually, in the sections seen by the writer, comes in in a wave-marked layer, six to ten inches thick. The top of this layer is usually so filled with the species that one can scarcely find a point on the rock that is not occuped by a specimen. The specimens are nearly always beautifully preserved, showing that they were not drifted, but apparently were imbedded where they grew.

This lower part of the *Strophomena* zone, characterized by the above-named abundant brachiopods, might very well be separated out as a distinct zone. *Leptaena rhomboidalis* extends nearly throughout it, and could give its name to the zone. A glance at the chart will show that with *Leptaena rhomboidalis* appear a considerable number of other species. Chief of these are *Platystrophia laticosta, Hebertella sinuata,* and *Rafinesquina loxorhytis,* which all have about the same range in this part of the section. Other species that appear or reappear at this same level are *Rhombotrypa quadrata, Prasopora hospitalis,* and *Dekayia pro-*

lifiica, all of which are common in this (*Leptaena*) zone, though extending beyond it. The *Leptaena* zone will also be found to be persistent in the Indiana region.

Faunally the *Strophomena planumbona* zone (Liberty beds) is thus seen to be pre-eminently a brachiopod zone, although other fossils are not wanting, and several of the bryozoa are abundant. It is also interesting for the number of species that represent recurrences of species that are known from lower zones. *Platystrophia laticosta* and *Hebertella sinuata* are Lorraine forms. *Leptaena rhomboidalis* occurs in the Trenton; *Plectambonites sericeus* in the Trenton and Eden formations. *Rhynchotrema capax* is apparently a lineal descendant of the Trenton *R. increbescens* (*R. inaequivalve*); and *Prasopora hospitalis,* considered by Nicholson as a variety of *P. selwynii* of the Trenton rocks, is at all events more suggestive of the Trenton faunas than of anything else.

On the Lithological side this zone is characterized by predominance of Limestone layers. Some of these layers attain a considerable thickeness (for the Cincinnati series), eight inches to a foot not being unusual. Especially toward the top of the zone the limestone layers are strong and frequently very fine-grained and barren of fossils. The most striking thing about the Liberty beds, next to their pronounced faunal characters, is the presence of these well-defined layers of Limestone, separated by comparatively thin layers of shale. In the southern part of the Indiana area the upper layers become more argillaceous, even slightly arenaceous, and contain very few fossils. This phase can be seen between Versailles and Madison.

Good exposures of this zone can be seen on Tanner's Creek, especially in the new railroad cuts (Nos. XVI and XVII); at the eighty-foot cliff on the west fork of Cedar Creek, north of Versailles; at the south end of the Big cut, at Madison; on Big and Little Sains Creeks near Laurel; along Elkhorn Creek south of Richmond; in the quarries and along the gorge south of Richmond (1.41D), and at the type locality near Liberty, Indiana.

The *Tetradium* zone or Saluda formation immediately succeeds the *Strophomena* zone, and presents the most peculiar set of lithological characters of any zone in the Cincinnati series. In the southern part of the Indiana region nearly all of the zone is argillaceous or arenaceous. The rock as it occurs at Madison and Hanover has been variously described as argillaceous limestone, arenaceous limestone, calcareous sandstone, calcareous shale, etc. As a matter of fact, even the most arenaceous portions of this rock will usually be found to contain more or less lime carbonate; and the more calcareous layers will usually contain more or less argillaceous or arenaceous material. The zone in this southern area presents every evidence of shore-line deposition. Not only the presence of the coarser terrigenous sediments, but the ripple marks and sun-cracks that abound in the more shaly layers, and the presence of reef-building corals (*Tetradium* and *Columnaria*) attest this fact. In the northern portion of the Indiana area, on the other hand, the *Tetradium* zone has been difficult to recognize, and as I shall now show has *not* heretofore been properly located in the Richmond section. In order to elucidate this point I have prepared a series of carefully measured sections from Madison on the south to Richmond on the north. These sections are plotted to scale in Pl. E. In the construction of this diagram the various sections are set up on the horizon of the lowest *Tetradium* reef which is a persistent layer in all of the sections. The sections are spaced out along the diagram to the true scale of miles, which is given on the heavy line that marks the horizon of the lower *Tetradium* reef. The vertical scale of the sections is of necessity much exaggerated, but is the same for all of the sections. This scale is given on the left margin of the Madison section.

Beginning now at Madison, the section will be seen to contain two layers characterized by *Columnaria alveolata,* separated from each other by an interval of about six feet of argillaceous rock. The upper one of these reefs, as can be seen from the sections farther north, is the horizon of *Tetradium,* which does not seem to occur at Madison. Seven feet above the upper *Columnaria* reef is the base of the thick bed of calcareous sandstone that forms the conspicuously overhanging layers in the Big cut and at the Hanging Rock, and in the Falls about Hanover. This bed in the Madison section is 18 feet thick, and is arenaceous throughout. At the top of this arenaceous bed and separating it from the more argillaceous and calcareous beds above is a hard, strong layer of limestone (best seen in the falls in a small gully just north of the Big cut). Between this limestone layer and the Clinton comes about twenty feet of drab, mottled, argillaceous limestone.

We have, then, at Madison, the coral reefs overlain by a massive bed of sandstone, and this in turn overlain by a bed of impure limestone. Now, if this series be traced northward, it will be seen that the *Columnaria* of the upper reef is replaced by *Tetradium;* the massive bed of calcareous sandstone becomes thinner and more argillaceous, and the upper bed of argillaceous limestone becomes thicker and more varied in character, so that a number of well-defined divisions can be made out. Even in section No. 2, only five miles north of Madison, these latter characters begin to appear. The comparison of these sections can be carried out sufficiently well on the diagram, so that detailed discussion of each section is unnecessary. In the Versailles section *Columnaria* is absent, but the *Tetradium* is present in great numbers through a thickness of about nine feet of rock, being especially abundant in the lower part of this interval. Above this *Tetradium* reef comes the "Shale bed" of this report. This, it will be seen, is the representative of the massive sandstone bed of the Madison section. In the Versailles section this "shale bed" is eight and one-half feet thick, and is overlain and underlain by a hard, thick, strong layer of limestone. Above this "shale bed" come 18 feet of mottled argillaceous limestone, practically unfossiliferous. This bed is overlain by five feet of massive, thick limestone, quarried here and at Osgood for road metal. Above this bed comes a zone of nodular, shaly, highly fossiliferous limestone—the upper fossil bed of this report. The fauna of this last zone is significant in containing among other species *Monticulipora epidermata* and *Homotrypa wortheni,* two of the characteristic species of the Whitewater division of the Richmond section. The most abundant brachiopod of this bed is *Platystrophia acutilirata senex,* another Whitewater species.

The characters of the "shale bed" as they are exhibited in the sections about Versailles must be carefully noted in order to appreciate the extreme usefulness of this stratum in making out the stratigraphy of the sections farther north. It consists of a very sharply defined stratum of hard, slabby, calcareous, drab shale, conspicuously ripple-marked and sun-cracked, and is always overlain and underlain by firm, thick layers of hard, barren limestone, which sometimes on prolonged weathering tend to split into laminae similar to those of the shale bed. Below this bed at an interval of a few feet comes the *Tetradium* reef, and below the latter, in some of the sections, a *Columnaria* reef. Thus is formed by the "shale bed" and its associates an unmistakable horizon.

Going farther north, the same features are presented at Osgood, in the bed of the stream along the old right-of-way east of that town. Here the *Columnaria* is very abundant and beautifully preserved. Still farther north (Section No. 8), two miles north of Osgood, the "shale bed" may be seen in the bed of a small western tributary of Laughery Creek, underlain by the usual associates, the *Tetradium* and *Columnaria* reefs. In this section there is also a *Tetradium* reef 11 feet above the "shale bed." A *Tetradium* layer is also present 15 feet above the "shale bed" in section No. 5, south of Versailles. Aside from the presence of this *upper Tetradium* reef in this section there is very little departure from the appearances presented in the Versailles section. About 23 feet above the shale bed in this section is the upper fossil bed, which here contains *Strophomena sulcata* and *Streptelasma divaricans,* two more of the characteristic fossils of the Whitewater division. This bed is separated from the Clinton by an interval of about 15 feet of apparently rather hard, barren limestone.

On West Laughery Creek, about a mile southwest of Ballstown, are numerous fine exposures of these beds. Section No. 9 is typical of these exposures. In this section the *Tetradium* reef, underlain by the *Columnaria* reef, is separated by an interval of 10 feet from the "shale bed." The latter is 6 feet 8 inches thick, and is overlain and underlain as usual by massive layers of limestone. The upper fossil bed is separated from the "shale bed" by about 23 feet of mottled limestone, and here again *Streptelasma divaricans* and *Strophomena sulcata* are common.

Two miles west of Hamburg, Franklin County, on a small western tributary of Big Salt Creek, occur exceptionally fine exposures of these beds. Here the entire interval from the "shale bed" to the Clinton is exposed. The "shale bed" is only two feet thick in this section, but between it and the upper massive layer of limestone is a stratum of three feet four inches of thin limestone layers, which undoubtedly is the calcareous representative of the upper part of the "shale bed." In this section the lower *Tetradium* reef is five feet below the "shale bed" and the upper *Tetradium* reef is 20 feet above the "shale bed." Fifteen feet above the upper *Tetradium* reef in a layer of blue, nodular, soft limestone, occur numerous typical examples of *Rhynchotrema dentata.* Associated with this species are *Monticulipora epidermata, Streptelasma divaricans, Strophomena sulcata,* and *Platystrophia acutilirata* var. *senex.* This, it will be seen, is a typical Whitewater fauna, *occurring 40 feet above the "shale bed."* It may be remarked in passing that the "shale bed" in this section in everything but its lessened thickness is perfectly typical and has all of the usual associates.

The next section of interest is five and one-half miles southwest of Laurel on a small western tributary of Big Salt Creek. In this section the two *Tetradium* reefs are present and are separated from each other by an interval of about 20 feet as in the preceding section. At the horizon of the shale bed in this section we have instead of the usual sun-cracked, slabby shale, four feet of thin limestone, overlain and underlain by the usual massive, hard, barren layers of limestone. In other words, the "shale bed" has become completely calcareous, owing to the constantly increasing distance from the shore line as we go northward. The associates are there in this case, but not the shale bed. From now on, therefore, we shall have to speak of the massive limestone bed, or "massive bed." The *Tetradium* occurs in the usual abundance in the lower part of this "massive bed." *Columnaria* is absent, as it is in all sections north of this one. In the other sections about Laurel the appearances are substantially as in the section just described, and can be sufficiently well made out in the diagram, and in the detailed descriptions of the sections. One point needs mention, namely, that in the sections on Big Sains Creek there is associated with the massive bed more or less black carbonaceous shale, of the same sort as that seen above the shale bed in the cut north of the station at Weisburg, and in association with the massive bed in the Richmond section, as will be pointed out presently. (See Figs. 7 and 16.)

East and north of Laurel, good sections are infrequent. On the headwaters of Big Duck Creek, three miles northeast of Laurel, there is, however, a very good section exposing nearly all of the layers from the *Plectambonites sericeus* stratum to the "massive bed." Here the "massive bed" is separated from the wave-marked *Plectambonites* layer by an interval of 50 feet, occupied by the typical rocks and fauna of the Liberty formation. The *Tetradium* is present in the usual abundance.

The next section is east of Whitewater River, about two and a half miles southeast of Quakertown, in Union County. Here the "massive bed" with the *Tetradium* is 45 feet above the *Plectambonites* layer.

At Liberty there is an excellent exposure of the beds named from that place, along a small stream emptying into Silver Creek about a mile west of the center of the city. The "massive bed" containing *Tetradium* is here also 45 feet above the *Plectambonites* layer.

The next section is the exceptionally fine series of exposures along Elkhorn Creek, four miles south of Richmond. In this section nearly every layer is exposed from the base of the Liberty beds to the Clinton limestone. Here, also, as in the sections just

Fig. 15.—Upper fossil bed on creek along "Right-of-way," east of Osgood, with a massive bed of limestone beneath.

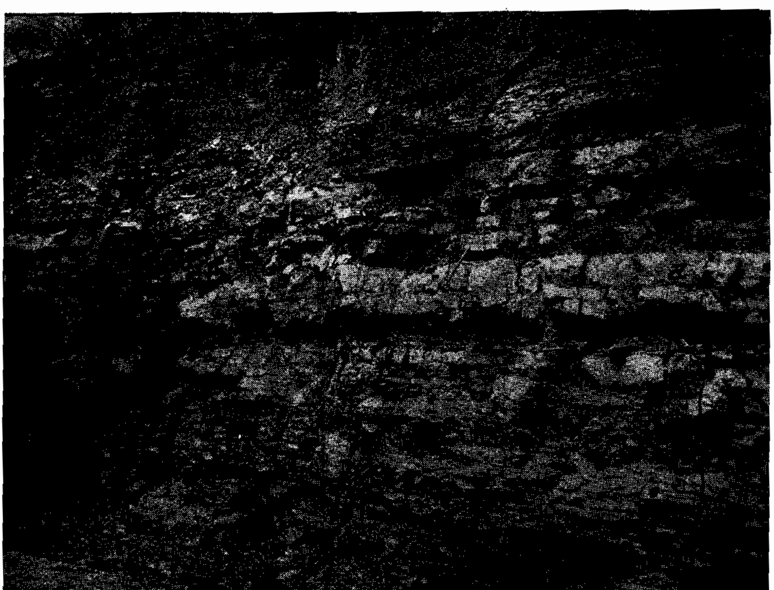

Fig. 16.—Top of shale bed in Cut No. XVIII north of Weisburg station. The hammer rests on the *Tetradium* layer *a*. Just below this layer is the bed of black carbonaceous shale *b*, and below this the "shale bed" *c*.

described, is present, at an elevation of 40 feet above the *Plectambonites* layer, the "massive bed" of limestone containing *Tetradium*. Here, however, the *Tetradium* is rare and consists of small and imperfect specimens. About 40 feet above this massive bed is the base of the zone of *Rhynchotrema dentata*. The interval is here occupied by nodular limestone and shale in which there is a fauna chiefly characterized by the abundance of *Rhynchotrema capax* and *Platystrophia acutilirata*. Above the *Rhynchotrema dentata* zone, which is about 35 feet thick, come 15 feet of very soft blue shale, and above this 25 feet of blocky, argillaceous-calcareous shale, which is capped by six feet of hard, brown limestone. The latter stratum is separated from the Clinton by four feet of clay. This upper zone, between the top of the *Rhynchotrema dentata* zone and the Clinton, is characterized by the abundance of a variety of *Platystrophia lynx* (*P. lynx* var. *moritura*), and is named in this report the *Elkhorn* division of the Richmond series. Faunally it is to be known as the *moritura* zone. If we go back for a moment to the sections about Osgood, it will be seen that in the extreme top of these sections occurs a form of *Platystrophia lynx*, probably the same as that found in the Elkhorn division. In the section (1.64B) west of Hamburg there occurs directly underneath the Clinton a bed of dark-colored, coarse limestone, very similar to that in the upper part of the Elkhorn division at Richmond, and containing the same species, *Platystrophia moritura* and *Hebertella sinuata*. This association of species can also be seen in the sections west of Laurel (1.14F, etc.) in a similar limestone and at the same horizon. We evidently have here in the more southern sections the thinned representative of the Elkhorn division, as we have just seen that these sections contain a thinned representative of the Whitewater division.

In the section exposed along the Whitewater River at Richmond the "massive bed" is beautifully shown at the quarries near the Steel bridge, south of the city. Here no specimens of *Tetradium* were found after a prolonged search. The other characteristics of the bed are typical. One feature of this massive limestone bed (which in the great thickness of the layers itself is unusual for the Cincinnati group) that is seen in the more northern exposures is the presence of large pockets of calcite crystals. This feature is well shown at the quarries. Here, also, the dark carbonaceous shale is seen associated with the bed as in the Laurel and Weisburg sections. Taking this association of lithological characters in connection with the interval between this bed and the *Plectambonites* layer, and the fact that the bed can be traced almost continuously from the region of Hamburg and Laurel, where it is definitely and undeniably shown to be the same horizon as the "shale bed," and adding to this the fact that the fauna of the Whitewater occurs well above the "shale bed" at Hamburg, Osgood and Versailles, it seems to me certain that the massive bed of the Richmond section is the northern representative of the shale bed and the lower *Tetradium* reef.

What now is the general conclusion of this discussion of the stratigraphy of the *Tetradium* zone? First of all, as stated above, the "massive bed" of the Richmond section is the calcareous representative of the "shale bed" and the *Tetradium* reef. This bed has a total thickness at Richmond of about six feet. Second, the same zone in the Madison section is 30 feet thick (the shale bed plus the two coral reefs). Third, the mottled bed of the Madison section represents some portion of the Whitewater division, modified lithologically and faunally by proximity to the shore-line. Fourth, the rest of the Whitewater division and probably all of the Elkhorn division is lacking in the Madison section. This last conclusion carries with it the further conclusion that, fifth, there is an unconformity at the top of the Ordovicion system, and the Madison region was above water while these upper beds at Richmond were being deposited.

In regard to this last point, it may be said that the presence of an unconformity does not rest solely upon the facts presented above. Foerste has shown in his various papers on the Silurian rocks of Indiana that the Clinton varies greatly in thickness, being sometimes totally lacking; that it often contains fragments of Ordovician limestone, sometimes amounting to a veritable breccia; and that the surface of contact of the Ordovician and Silurian is far from uniform.

That the above interpretation of the facts shown by the sections of the upper part of the Cincinnati group is very different from past and current interpretations is very evident. To those who may be inclined to question my view of the subject I may say that the *facts* are mostly new; that our conclusions in regard to the stratigraphy of the Richmond series have heretofore been based upon very insufficient evidence; and that these sections presented and discussed in the present report are the first series of carefully measured sections of this series of rocks ever published.

GENERAL PROBLEMS.

The discussion of the stratigraphy of the Cincinnati rocks cannot be concluded without some mention of the exceedingly interesting general problems presented by both the lithological and faunal sequence represented in this series of deposits. No one who sees these rocks in the field can fail to be impressed first of all by the wonderful succession of thin argillaceous limestones and shales. Scarcely any of the limestone layers are pure; they nearly always contain more or less terrigenous material. On the other hand, most of the shale is more or less calcareous. The physical conditions suggested are those of a rather shallow epicontinental sea receiving fine silt from a low-lying land surface on which a moist climate afforded the conditions for rather complete chemical disintegration of the rocks.

The interminable succession of limestone and shale layers has ordinarily been looked upon as suggesting a continual, slow oscillation of the sea level up and down. While it may be necessary to call in this familiar process to account for some of the larger variations in the type of sediment, such, for example, as the change from predominant shale in the Eden to predominant limestone in the Lorraine; and back to shale in the lower Richmond; I am inclined to think that the possibilities in the way of alternative explanations of these changes in the type of sediment have not by any means been exhausted.

First of all, for the minuter alternation of calcareous and terrigenous sediments, I think we may look to climatic rather than to epeirogenic changes; and these climatic changes need not, it seems to me, be of great magnitude. It is well known that lime-secreting organisms, such as make up the faunas of the Cincinnati series (bryozoa, brachiopods, etc.), require, not deep, but merely clear water of the favorable temperature, and with the proper food supply. For such organisms an influx of even a small amount of mud is a prohibitive condition. It is then the cause of the alternation of comparatively clear and comparatively muddy water conditions that we seek; and it is precisely here that changes in climatic conditions—in the relative humidity—come in play. It is, of course, a well-known fact that the greater part of the silt supplied to the deltas of rivers is brought down during a comparatively small portion of the year, that is, there is an annual variation in the supply of silt. It is doubtful if this small-period fluctuation in the supply can be recognized in a geological formation.

It may account, as suggested by Gilbert, for some part of the lamination of shales. There are, however, certain more or less definite variations of longer period, in the amount of rainfall, such, for example, as the eleven-year and the thirty-six-year cycle. In addition to these there are still more pronounced climatic changes, of unknown cause, extending over long periods of time, which might account even for some of the larger variations in the type of sediment. It is thought that the variation in the amount of terrigenous sediment, necessary to produce the change from impure limestone to calcareous shale, is not necessarily very great. The influx of a small amount of mud may be sufficient to drive out such organisms as the *Trepostomata* and many of the *Brachiopoda* (some of the latter, for example *Rafinesquina alternata,* seem to have been able to accommodate themselves to a considerably increased supply of mud); and since this cuts off the supply of calcareous ooze, it acts in a two-fold way to cause the accumulation of a deposit of sediment comparatively free from lime. For, first, since the limestones of the Cincinnati series are in general impure, the indications are that *some* terrigenous material was accumulating over the sea bottom at all times, and if the usual supply of lime from lime-secreting organisms was for any reason cut off, there would arise, from this cause alone, a deposit of mud. What is needed, therefore, is a rather delicate adjustment of the majority of lime-secreting organisms to nearly clear water, and a relatively small variation in the climatic conditions on the land surface that is the source of supply of the silt. Both of these requirements find ample illustration, it seems to me, in present-day conditions.

Another cause of the interleaving of calcareous and terrigenous sediments that may legitimately be appealed to, I believe, is the shifting position and strength of currents, especially shore currents, undertow, and tidal currents; since it is these currents that are chiefly instrumental in distributing the sediments to various parts of the sea bottom. Now the rate and amount of change in the strength of shore currents and of the undertow, are dependent upon the varying strength of the wind. In time of great storms, comparatively coarse sediment may be carried out to considerable distances from land. We may very likely have in the occasional very thin layers of sandstone in the Eden shales an illustration of this last phenomenon. To what extent the varying strength of currents, due to the varying force of the wind, may have produced successive layers of shale and limestone, is a question that has not received the attention that it merits. It would seem to me that some of the thinner bands of shale intercalated with the limestone layers may have been due to this cause.

The shifting of the position and direction of currents is ordinarily due to changes in the contour of the coast line; and these may be brought about by erosion and deposition along the coast. Where the wind is variable in direction there is a continual shifting of the position and direction of shore currents from this cause. In some climates there is a seasonal change of the direction of the wind that may produce marked shifting of the position and direction of shore currents. Other changes of longer period may correspond to the long period climatic changes already mentioned. The changes in the direction, position and force of currents due to the causes enumerated above must direct the chief supply of silt, now to one part, and now to another part of the sea bottom. Probably only the longer period changes of this sort have had much to do with producing distinct beds of limestone and shale, for lime-secreting organisms could not gain a footing in a locality subject to very frequent influxes of muddy water. That the arrangement of the layers of shale and limestone in the Cincinnati series is not adverse to the above interpretation seems to me certain. Any measurement of two sections of the same stratigraphic interval in two nearby localities will always show considerable differences in the details, showing that the thinner beds are constantly pinching in and out. This indicates that the limestone was accumulating in patches over the sea bottom. While this may be due in part to the fact that organisms tend to live in colonies, it may also very possibly be due to the shifting about of the supply of terrigenous silt, in the manner above described. Another fact of frequent observation in the Cincinnati rocks that bears upon the same question is the evidence that many times great numbers of organisms were rather suddenly buried where they grew. The presence of immense numbers of perfectly preserved fossils along the plane of contact between a limestone and a shale stratum indicates this. Some more or less sudden increase in the supply of material, or change in the direction or force of the transporting agent is indicated. The presence of definite currents along the sea bottom is indicated by the rather common occurrence of immense numbers of flat shells, such as those of *Rafinesquina alternata,* arranged edgewise like the "shingle" along the bed of a stream; and a considerable agitation of the water, at times, is proved by the wave-marked layers of limestone that occur at several levels in the Cincinnati series. The latter may be due to storms of exceptional violence, or possibly to very exceptional oscillations of the water generated by earthquake shocks. Some of these wave-marked layers seem to have very wide extent, as, for example, the layer in which *Plectambonites sericeus* occurs so abundantly, near the base of the Liberty formation.

To sum up this discussion: There seems to be no necessity, in the case of the greater number of smaller alternations of shale and limestone in the Cincinnati rocks, to appeal to epeirogenic causes, as has ordinarily been done. These alternations may be explained by calling into play only the well-known processes that are going on on any sea bottom, not too deep or too far removed from the land. Even the larger variations in the type of sediment may be due to the larger variations in the same set of causes. Where a new fauna comes in suddenly, however, as in the base of the Liberty, we may probably look to epeirogenic readjustments to account for both the change in the fauna and the change in the type of sediment.

The problems presented by the faunal succession in the Cincinnati series are still more interesting than those presented by the lithological succession. In the paper by Nickles on the Geology of Cincinnati (*ante*), thirty-two species are listed, out of over 600 that occur in the Cincinnati region, as ranging throughout the Cincinnati series. For a thickness of 700 feet of rocks this is a surprisingly small number. If these species be examined, it will be seen that they also, for the most part, occur in the Trenton series, so that they represent a fauna inherited from the preceding epoch. It is interesting that only three of these widely ranging species are Bryozoa, and these three (*Stomatòpora arachnoidea, S. delicatula* and *Ceramoporella ohioensis*) belong to the most primitive type of that class, showing the persistence of unspecialized types. A few other species that are present in the Trenton reappear here and there in the Cincinnati series but do not extend through it. Such, for example, are *Plectambonites sericeus, Platystrophia lynx, Leptaena rhomboidalis,* etc.; the first and last appearing in the Richmond formation where they are associated with a number of other species more or less closely related to Trenton forms (*Rhynchotrema capax, Dinorthis subquadrata, Streptelasma rusticum, Protarea vetusta, Prasopora hospitalis,* and a large number of Homotrypas, a genus that finds its fullest representation in the Trenton).

While, therefore, the aspect of the Cincinnati faunas is a constantly changing one, the changes seem to be due more to a rather quiet evolution within the area of the epicontinental sea occupied by these faunas, than to any pronounced irruptions of species from other provinces, if we except the influx of outsiders in the Richmond. Such facts as the reappearance of *Platystrophia lynx* in the Lorraine (it is quite lacking in the Eden) or the appearance of the large group of *Heterotrypidae* in the same formation, may be explained by the probability that these forms or their immediate ancestors were living in some portion of the same general province during Eden time. The family of Bryozoa mentioned has representatives in the Eden (*Dekayia ulrichi,* etc.) as well as in the Trenton. In the Lorraine it deployed into a large group of species, all of which are nearly enough related to represent an intra-provincial evolution. If we take another group of Bryozoa, the genus *Callopora,* which is also well represented in the Trenton, we find the Lorraine species related rather to the Eden than to the Trenton forms. *Callopora dalei* of the lower Lorraine is related to *C. communis* of the upper Eden and still more closely, probably intimately, to *C. nodulosa* of the Eden. *C. ramosa* again shows transitional forms to *C. dalei,* the latter being regarded as a variety of the former by Nicholson. Again *C. rugosa* of the upper Lorraine is an undoubted variety of *C. ramosa.* Another genus, *Amplexopora,* is represented in the upper Eden and lower Lorraine by the species *A. septosa,* and its variety *multispinosa.* Later are produced in the middle and upper Lorraine *A. cingulata* and *A. robusta,* both close relatives of *A. septosa;* and in the very top of the Lorraine, the species *A. pustulosa* (again closely related to *A. septosa*), the latter species extending on into the Richmond. The genus *Homotrypa* is represented in the Eden by a single species (or variety), *H. praecipta,* a variety of the common *H. curvata* of the Lorraine. The great deployment of these genera in the Lorraine seems to be sufficiently well explained by the more favorable conditions represented by the clearer waters of that epoch.

These favorable conditions of the Lorraine were terminated by an influx of muddy water, which gradually drove out the typical Lorraine fauna, and evidently was accompanied or perhaps produced by some more or less widespread epeirogenic disturbance. This gave us the fauna of the Waynesville, which was developed under similar conditions, and contains in some respects a similar group of species to the Eden. For example, *Dalmanella meeki* (or *jugosa*) takes the place of *D. multisecta* of the Eden, *Batostoma varians* is related rather closely to *B. jamesi* of the Eden, and *Bythopora delicatula* suggests *B. arctipora* of the Eden. There is also a small species of *Callopora* quite similar to *C. sigillaroides,* and what appears to be a species of *Dekayia* not unlike *D. ulrichi* of the Eden. In the upper part of the Waynesville the incursions of the outside species (*Leptaena rhomboidalis,* etc.) begin to be felt. One interesting fact connected with the basal member of the Richmond (Arnheim) is the presence, in a very thin zone, of the foreign species *Dinorthis retrorsa.*

The chief faunal fact of the Richmond is, as has been several times mentioned already, the coming in of a large number of species that find their nearest relatives in the Trenton series. Formerly it was quite the custom to refer these species to well-known Trenton forms. That this was a mistake has long ago been learned by the more careful studies of these faunas, which we owe to Mr. E. O. Ulrich more than to any other student of these rocks. The fact remains, nevertheless, that these species of the Liberty and Whitewater divisions of the Richmond find their nearest relatives, not in the Lorraine, but in the Trenton faunas. In my account of the Liberty formation, given above, I have brought out the leading facts bearing on this point. In the Richmond section the fauna of the Whitewater division succeeds that of the Liberty without break; but farther south in Indiana there is intercalated between these two divisions a coral reef and finally in the Madison region the Whitewater fauna is entirely lacking, the fossiliferous portion of the Richmond formation practically terminating at the base of the arenaceous Saluda beds. In the upper part of the Saluda beds in the Madison region and for a short distance northward, there is a meagre fauna (*Lophospira hammeli* and its associates). What portion of the sections farther north this zone corresponds to is not certainly known, but judging from the studies of Foerste, it should fall at about the level of my upper fossil bed (No. 11 of section 1.60H), and if this is the case, it may be a representative of some portion of the Whitewater division.

In the Richmond section there is also, as may readily be seen from the detailed section along Elkhorn Creek (1.41A), a very well-marked fauna above the Whitewater fauna, and separated from it by a band of nearly barren shale. This latter fauna is that of the *Platystrophia moritura* zone, or Elkhorn division of the Richmond. It is a very interesting fauna in that it presents a reappearance of a number of typical middle Lorraine species, as pointed out several years ago in my paper on the genus *Platystrophia*. Most interesting of these species are *Platystrophia lynx* var. *moritura* which differs very little from the large (normal) *lynx* of the top of the *Platystrophia* zone (Bellevue beds), and *Hebertella sinuata,* scarcely differing at all from the large Lorraine form. In addition to these two fossils the beds in question contain *Platystrophia laticosta,* and a *Callopora* not differing appreciably in external appearance from *C. ramosa.* On the other hand, they contain at least one form that is characteristic of the Whitewater beds, namely *Homotrypa wortheni,* and probably also the common Richmond bryozoan, *Prasopora hospitalis.* The return of these common Lorraine species of *Platystrophia* and *Hebertella* after an absence from nearly 400 feet of rock is certainly an interesting fact. It may point to the extermination of the extensive brachiopod fauna of the Liberty and Whitewater by the influx of terrigenous sediment at the beginning of the Elkhorn stage, thus leaving the field free, when the waters once again cleared, near the close of Richmond time, for the return of these old and long-lived inhabitants to their former haunts.

The presence of a coral reef separating the Liberty and Whitewater beds has already been mentioned. This zone of reef builders is best developed in the Madison region, probably because there the water was shallowest and the coast line near at hand. Tracing the coral zone northward, one of the genera, *Columnaria,* soon disappears but comes in again between Versailles and Hamburg, disappearing finally at the latter place. *Tetradium* can be traced north as shown further back, to Richmond, where it is very rare, and the specimens have the appearance of having been drifted. The presence of these corals is in line with the other evidences of the shoaling of the Richmond Sea, and the presence of a coast line not far southwest of the Madison region; a condition due, no doubt, to the culmination of the epeirogenic readjustment that had begun in Waynesville time, and had resulted, first in the lowering of some barrier, admitting an outside fauna, and finally, in Whitewater time, had probably brought the entire southern Indiana region out of water.

As to the bearing of these facts and interpretations upon other provinces, it seems to me, in the absence of equally detailed stratigraphic work in other places, to be rather too early to make any definite statements. The rocks called in this and other reports on the Cincinnati region, Lorraine, are, I am convinced, the homotaxial equivalents of the typical Lorraine of New York, or better, they are in large part equivalent. If this be true, and if the Richmond represents, as indicated above, a period of epeirogenic disturbance and readjustment, I think we are to look upon the Medina of New York as equivalent in part at least to the Richmond. Mr. Ulrich has already advanced this opinion, and I believe it will turn out to be correct. The Medina and Oneida represent the culmination of an elevatory movement and a readjustment of land and water relations that was undoubtedly widespread, and was followed by an equally widespread subsidence, that culminated in the limestone forming epoch of the Niagara. In the Indiana region there is no set of deposits that so well reprsents the culmination indicated by the Medina and Oneida sediments of the New York province as the later portions of the Richmond.

PART II: DESCRIPTION OF SPECIES.

COMPLETE LIST OF SPECIES REPORTED FROM THE CINCINNATI SERIES OF INDIANA, WITH THEIR HORIZON, SO FAR AS KNOWN.

CORALS AND SPONGES.

1. *Beatricea nodulata* Billings. See B. nodulosa Billings.
2. Beatricea nodulosa Billings. Saluda.
2a. Beatricea undulata Billings. Saluda.
3. Calapoecia cribriformis Nicholson. Lower Richmond.
4. Columnaria alveolata Goldfuss. Base of the Saluda.
5. *Columnaria inaequalis* Hall. Not a Cincinnati group species.
6. *Favistalla stellata* Hall. See Columnaria alveolata.
7. Labechia montifera Ulrich. Upper part of the Richmond formation.
8. Protarea vetusta Hall. Liberty and Whitewater divisions of the Richmond formation.
9. Strephochetus richmondensis Miller. Upper part of the Richmond formation. Whitewater.
10. *Streptelasma crassum* Hall. Not found in the Cincinnati group.
11. Streptelasma divaricans. Whitewater division of the Richmond formation.
12. *Streptelasma parvulum* Hall. Not a Cincinnati group species.
13. *Streptelasma radicans* Hall. Not a Cincinnati group species.
14. Streptelasma rusticum Billings. Liberty and Whitewater divisions of the Richmond formation.
15. *Stromatocerium richmondense* Miller. See Strephochetus richmondensis.
16. *Tetradium fibratum* Safford. The form that occurs in the Cincinnati group of Indiana is T. minus.
17. Tetradium minus Safford. Base of the Saluda and sparingly throughout the Saluda.

ECHINODERMATA.

18. Agelacrinus faberi Miller. Richmond formation.
19. Anomalocrinus incurvus Meek and Worthen. Richmond (?).
20. Dendrocrinus caesi Meek. Richmond.
21. Dendrocrinus polydactylus Shumard. Richmond.
22. Ectenocrinus simplex Hall. Richmond.
23. Glyptocrinus decadactylus Hall. Richmond (?).
24. Glyptocrinus dyeri Meek. Richmond.
25. Heterocrinus juvenis Hall. Lower Richmond.
26. *Idiocrinus subcrassus* Meek and Worthen. See Iocrinus subcrassus.
27. Iocrinus subcrassus Meek and Worthen. Lorraine. Richmond (?).
28. Lepadocrinus moorei Meek. Richmond.
29. Lepidodiscus faberi Miller. Richmond.
30. Lichenocrinus crateriformis Hall. Utica. Richmond (??).

31. Lichenocrinus dyeri Hall. Richmond.
32. Lichenocrinus pattersoni Miller. Richmond.
33. Lichenocrinus tuberculatus Miller. Richmond.
34. *Paleaster speciosa* Miller and Dyer. See paleasterina speciosa.
35. Paleaster wycoffi Miller and Gurley. Richmond.
36. Paleasterina speciosa Miller and Gurley. Richmond.
37. *Poteriocrinus casei* Meek. See Dendrocrinus casei.
38. *Poteriocrinites polydactylus* Shumard. See Dendrocrinus polydactylus.
39. *Protaster granuliferous* Meek. See Taeniaster granuliferous.
40. Urasterella grandis Meek. Richmond.
41. Taeniaster granuliferous Meek. Richmond.
42. Xenocrinus baeri Meek. Richmond.

BRACHIOPODA.

43. *Camarotoechia ventricosa* Hall. Not a Cincinnati group species.
44. Catazyga headi Billings. Richmond.
45. Crania laelia Hall. Liberty division of the Richmond formation.
46. *Crania reticularis* Miller. See Trematis reticularis.
47. Crania scabiosa Hall. Lorraine and Richmond.
48. Dalmanella emacerata Hall. Upper Eden shales.
49. Dalmanella meeki Miller. Waynesville. The characteristic fossil of this formation. (= D. jugosa James.)
50. Dalmanella multisecta Meek. Eden shales. The characteristic fossil of this formation.
51. Dinorthis retrorsa Salter. About the middle of the Arnheim.
52. Dinorthis subquadrata Hall. Middle portion of the Liberty.
53. *Hebertella borealis* Billings. Not a Cincinnati group fossil.
54. Hebertella insculpta Hall. Base of the Liberty beds. Characteristic fossil of this horizon.
55. Hebertella occidentalis Hall. Liberty and Whitewater divisions.
56. Hebertella sinuata Hall. Lorraine, Liberty, Whitewater and Elkhorn divisions.
57. Leptaena rhomboidalis Wilckens. Top of the Waynesville and base of the Liberty. Very common at this horizon.
58. *Leptaena transversalis* Wahlenberg. See Plectambonites transversalis.
59. Leptobolus lepis Hall. Lorraine.
60. Lingula covingtonensis Hall and Whitfield. Lower Eden.
61. *Orthis borealis* Billings. See Hebertella borealis.
62. *Orthis centrosa* Miller. See Platystrophia costata.
63. Orthis fissicosta Hall. Lorraine.
64. *Orthis tricenaria* Conrad. Not a Cincinnati group species.
65. Platystrophia acutilirata Conrad. Liberty and Whitewater divisions.
66. Platystrophia acutilrata var. senex Cumings. Upper part of the Whitewater division.
67. Platystrophia costata Pander. Lower Lorraine, and upper Eden (?).
68. Platystrophia lynx Eichwald. Lorraine. This is the characteristic fossil of the middle and upper part of this formation.

69. Platystrophia lynx var. laticosta Meek. Lorraine, Waynesville, Whitewater, Liberty and Elkhorn. The characteristic fossil of the lower and middle Lorraine.
70. Platystrophia lynx var. cypha James. Upper part of the Lorraine.
71. Platystrophia lynx var. moritura Cumings. Elkhorn division. This is the characteristic fossil of this division.
72. *Platystrophia unicostata.* See P. cypha.
74. Plectambonites sericeus Sowerby. Eden shales, Waynesville (rare), base of Liberty (very abundant), Whitewater (rare). This is one of the characteristic fossils of the base of the Liberty.
75. *Plectambonites transversalis* Wahlenberg. Not a Cincinnati group species.
76. Plectorthis ella Hall. Lorraine.
77. Plectorthis plicatella Hall. Lower Lorraine.
78. Plectorthis triplicatella Meek. Lower Lorraine.
79. Rafinesquina alternata Emmons. Throughout the Cincinnati group. Especially characteristic of the Arnheim.
80. *Rafinesquina alternata* var. *alternistriata.* Same as R. alternata.
81. Rafinesquina alternata var. fracta Meek. Top of Lorraine.
82. Rafinesquina alternata var. loxorhytis Meek. Top of Waynesville and base of Liberty.
83. Rafinesquina alternata var. nasuta Conrad. Upper Lorraine.
84. Rafinesquina alternata var. ponderosa Cumings. Upper Lorraine.
85. Retzia granulifera Meek. Upper Eden.
86. *Rhynchonella ventricosa.* Hall. See camarotoechia ventricosa.
87. Rhynchotrema capax Conrad. Liberty and Whitewater divisions.
88. Rhynchotrema dentata Hall. Liberty (very rare). Whitewater. This is the characteristic Brachiopod of the Whitewater division.
89. Schizocrania filosa Hall. Trenton to Lorraine.
90. *Streptorhynchus elongatum* James. See Strophomena planumbona.
91. *Streptorhynchus vetustum* James. See Strophomena vetusta.
92. *Strophomena incurvata* Shepard. Not a Cincinnati group species.
93. Strophomena neglecta Meek. Liberty and Whitewater divisions.
94. Strophomena planumbona Hall. Liberty (common), Whitewater. This is the characteristic brachiopod of the Liberty division.
95. Strophomena planoconvexa Hall. Lorraine.
96. Strophomena sinuata Meek. Lower Lorraine.
97. Strophomena subtenta Hall. Liberty.
98. Strophomena sulcata Verneuil. Top of the Liberty (rare). Whitewater division (common). This is one of the characteristic fossils of the Whitewater division.
99. *Strophomena tenuistriata* Sowerby. See Leptaena rhomboidalis.
100. Strophomena vetusta James. Lower Richmond (?). (See S. neglecta Meek.)
101. Trematis millepunctata Hall. Not common throughout the Cincinnati series.
102. Trematis reticularis Miller. Lorraine.
103. *Triplesia cuspidata* Hall. Not a Cincinnati group species.
104. Zygospira cincinnatiensis Meek. Upper and middle Eden shales.

105. Zygospira headi Billings. See Catazyga headi.
107. Zygospira modesta Hall. Throughout the Cincinnati group in nearly every layer of limestone.

BRYOZOA.

108. Amplexopora cingulata Ulrich. Middle and upper Lorraine.
109. Amplexopora multispinosa Cumings. Top of the Eden and base of the Lorraine.
110. Amplexopora petasiformis (Nicholson). Eden.
111. Amplexopora pustulosa Ulrich. Upper Lorraine and Lower Richmond.
112. Amplexopora robusta Ulrich. Middle Lorraine.
113. Amplexopora septosa (Ulrich). Lower Lorraine.
114. Arthropora cleavlandi (James). Upper Eden.
115. Arthropora shafferi (Meek). Lorraine and Richmond. A common fossil.
116. Arthrostylus tenuis (James). Upper Eden.
117. Atactoporella multigranosa (Ulrich). Lower and middle Lorraine.
118. Atactoporella mundula (Ulrich). Middle Lorraine.
119. Atactoporella newportensis Ulrich. Lower Eden.
120. Atactoporella ortoni (Nicholson). Middle Lorraine.
121. Atactoporella schucherti Ulrich. Lorraine and Richmond.
122. Batostoma implicatum (Nicholson). Middle and upper Eden. Common.
123. Batostoma jamesi (Nicholson). Middle and upper Eden.
124. Batostoma variabile Ulrich. Upper Richmond.
125. Batostoma varians (James). Arnheim, Waynesville and Liberty divisions of the Richmond. Common.
126. Bernicea primitiva Ulrich. Richmond.
127. Bythopora arctipora (Nicholson). Eden. Very common.
128. Bythopora delicatula (Nicholson). Richmond. Common.
129. Bythopora gracilis (Nicholson). Middle and upper Lorraine. Abundant.
130. Bythopora meeki (James). Waynesville, Liberty and Whitewater divisions of the Richmond. Common.
131. Bythopora striata Ulrich. Waynesville, Liberty and Whitewater divisions of the Richmond. Rare.
132. Callopora andrewsi (Nicholson). Upper Lorraine.
133. Callopora dalei (Edwards and Haime). Lower Lorraine. Very common.
134. Callopora frondosa Cumings. Whitewater division.
135. Callopora nodulosa (Nicholson). Upper Eden.
136. Callopora onealli (James). Lower Eden.
137. Callopora onealli communis (James). Upper Eden. Very abundant.
138. Callopora onealli sigillaroides (Nicholson). Eden. Common.
139. Callopora ramosa (d'Orbigny). Middle and upper Lorraine. Very common. A characteristic fossil of this part of the Lorraine.
140. Callopora ramosa rugosa (Edwards and Haime). Upper Lorraine. Common.
141. Callopora cf. ramosa. At several levels in the Richmond.

142. Callopora cf. rugosa. In the upper part of the Whitewater division.
143. Callopora subplana Ulrich. Lower Lorraine and upper Eden.
144. Callopora subnodosa Ulrich. Throughout the Richmond series. Common.
145. Calloporella circularis (James). Lower Richmond.
146. Ceramoporella distincta Ulrich. Eden.
147. Ceramoporella granulosa Ulrich. Eden and Lorraine.
148. Ceramoporella ohioensis (Nicholson). Throughout the Cincinnati series. Common.
149. Chiloporella flabellata Ulrich. Upper Lorraine.
150. Coeloclema alternatum (James). Middle and upper Eden.
151. *Coeloclema concentricum* (James). See C. commune Ulrich.
152. Coeloclema commune Ulrich. Eden.
153. Coeloclema oweni (James)*. Associated with the gerontic form of *Platystrophia lynx* in the upper part of the Lorraine.
154. Constellaria constellata (Vancleve) Dana. Lower Lorraine.
155. Constellaria constellata prominens Ulrich. Base of Lorraine.
156. Constellaria limitaris (Ulrich). Liberty division.
157. Constellaria polystomella Nicholson. Liberty and Whitewater divisions.
158. Dekayia appressa Ulrich. Upper Lorraine.
159. Dekayia aspera (Edwards and Haime). Lower and middle Lorraine.
160. Dekayia cystata Cumings. Middle Lorraine.
161. Dekayia frondosa (d'Orbigny). Lorraine.
162. Dekayia inflecta (Ulrich). Upper Lorraine.
163. Dekayia lobata Cumings. Middle Lorraine.
164. Dekayia magna Cumings. Middle Lorraine.
165. Dekayia obscura (Ulrich). Upper Eden.
166. Dekayia paupera (Ulrich). Upper Lorraine.
167. Dekayia pelliculata Ulrich. Upper Lorraine.
168. Dekayia prolifica (Ulrich). Waynesville, Liberty and Whitewater divisions of the Richmond. Especially abundant at the base of the liberty.
169. Dekayia subfrondosa Cumings. Lower Lorraine.
170. Dekayia subpulchella (Nicholson). Lower Lorraine. Whitewater (?).
171. Dekayia subramosa (Ulrich). Whitewater.
172. Dekayia ulrichi (Nicholson). Upper Eden. This is the characteristic fossil of the upper Eden.
173. Dekayia ulrichi robusta (Foord). Upper Eden.
174. Dicranopora emacerata (Nicholson). Lorraine and Richmond. Common.
175. Dicranopora fragilis (Billings). Lower Richmond (?).
176. Eridotrypa simulatrix (Ulrich). Waynesville and Liberty divisions of the Richmond.
177. Escharopora acuminata (James). Lower Eden.
178. Escharopora falciformis (Nicholson). Lower Lorraine.
179. Escharopora pavonia (Edwards and Haime). Lower Lorraine.
180. Fenestella granulosa Whitfield. Liberty and Whitewater divisions.

*This species was collected on Tanner's creek, after the greater part of my manuscript had gone to the printer.

181. Graptodictya perelegans (Ulrich). Waynesville.
182. Helopora elegans Ulrich. Liberty, Whitewater.
183. Helopora harrisi James. Lower Richmond.
184. Homotrypa austini Bassler. Liberty, Whitewater.
185. Homotrypa communis Bassler. Waynesville. Common.
186. Homotrypa constellariformis Cumings. Saluda and Whitewater (at Versailles).
187. Homotrypa curvata Ulrich. Lower Lorraine (?), and upper Lorraine.
188. Homotrypa cylindrica Bassler. Whitewater.
189. Homotrypa dawsoni (Nicholson). Arnheim, Whitewater (rare).
190. Homotrypa flabellaris Ulrich. Liberty and Whitewater. Common.
191. Homotrypa flabellaris frondosa Cumings. Arnheim.
192. Homotrypa flabellaris spinifera Bassler. Whitewater.
193. Homotrypa nicklesi Bassler. Whitewater.
194. Homotrypa nitida Bassler. Upper Richmond.
195. Homotrypa obliqua Ulrich. Lorraine.
196. Homotrypa praecipta Bassler. Upper Utica and lower Lorraine.
197. Homotrypa ramulosa Bassler. Liberty, Whitewater.
198. Homotrypa wortheni (James). Whitewater and Elkhorn. Common.
199. Homotrypa wortheni prominens Bassler. Extreme upper part of the Liberty and Elkhorn.
200. Homotrypella rustica Ulrich. Whitewater. Common.
201. Leptotrypa calceola (Miller and Dyer). Lower Lorraine.
202. Leptotrypa clavacoidea (James). Upper Lorraine.
203. Leptotrypa discoidea (Nicholson). Upper Lorraine (?), lower Lorraine.
204. Monotrypella aequalis Ulrich. Lower and middle (?) Eden.
205. *Monotrypella quadrata* (Rominger). See Rhombotrypa quadrata.
206. *Monotrypella subquadrata* Ulrich. See Rhombotrypa subquadrata.
207. Monticulipora epidermata Ulrich and Bassler. Whitewater. This is one of the most abundant and characteristic bryozoa of the Whitewater beds at Richmond.
208. *Monticulipora irregularis* Ulrich. See Stigmatella irregularis.
209. Monticulipora mammulata d'Orbigny. Upper Lorraine. Common and characteristic.
210. *Monticulipora molesta* Nicholson. See M. mammulata.
211. Monticulipora parasitica Ulrich. Liberty and Whitewater divisions.
212. Nicholsonella vaupeli (Ulrich). Upper Lorraine and base of Liberty, and upper part of Whitewater.
213. Peronopora pavonia (d'Orbigny). Lorraine and Richmond.
214. *Peronopora decipiens* (Rominger). See P. pavonia.
215. Peronopora vera Nickles. Eden.
216. Petigopora asperula Ulrich. Middle and upper Lorraine.
217. Petigopora gregaria Ulrich. Upper Lorraine.
218. Petigopora petechialis (Nicholson). Lorraine, Richmond (?).
219. Prasopora hospitalis Nicholson. Throughout the Richmond. Common.
220. Proboscina auloporoides (Nicholson), Lorraine and Richmond.
221. Proboscina frondosa (Nicholson). Lorraine and Richmond.

222. Ptilodictya plumaria James. Whitewater.
223. Rhombotrypa crassimuralis (Ulrich). Upper part of the Whitewater.
224. Rhombotrypa quadrata (Rominger). Waynesville, Liberty and Whitewater divisions of the Richmond. A very common fossil.
225. Rhombotrypa subquadrata (Ulrich). Base of the Liberty (?).
226. Rhopalonaria venosa Ulrich. Upper part of the Waynesville and base of the Liberty.
227. Rhinidictya lata (Ulrich). Waynesville.
228. Rhinidictya parallela (James). Lower Eden.
229. Spatiopora maculosa Ulrich. Lower Lorraine.
230. Spatiopora tuberculata (Edwards and Haime). Lorraine and Richmond.
231. Stictoporella flexuosa (James). Lower and middle Eden.
232. Stigmatella clavis (Ulrich). Eden.
233. Stigmatella crenulata Ulrich and Bassler. Waynesville.
234. Stigmatella irregularis (Ulrich). Lower Lorraine. Not certainly known to occur in Indiana.
235. Stigmatella personata Ulrich and Bassler. Elkhorn.
236. Stigmatella spinosa Ulrich and Bassler. Upper Richmond.
237. Stomatopora arachnoidea (Hall). Eden, Lorraine and Richmond.
238. Stomatopora inflata (Hall). Eden, Lorraine and Richmond.

GASTEROPODA AND PTEROPODA.

239. *Bellerophon bilobatus* Sowerby. See Protowarthia bilobata.
240. Bellerophon gorbyi Miller. Lorraine (?).
241. Bellerophon mohri Miller. Middle Richmond.
242. Bellerophon subangularis Ulrich. Middle Richmond.
243. Bucania crassa Ulrich. Uppermost beds of the Richmond.
244. *Bucania expansa* Hall. See Salpingostoma expansa.
245. Bucania simulatrix Ulrich. Whitewater.
246. Clathrospira subconica (Hall). Lorraine and Richmond.
247. Conradella dyeri (Hall). Richmond.
248. *Conradella dyeri cellulosa* Ulrich. Not found in the Cincinnati group.
249. Conularia formosa Miller and Dyer. Richmond.
250. Cyclonema bilix (Conrad). Richmond.
251. *Cyclonema bilix conicum* Miller. See C. bilix.
252. Cyclonema bilix fluctuatum (James). Richmond.
253. Cyclonema bilix humerosum Ulrich. Upper half of the Lorraine, and Richmond.
254. Cyclonema bilix mediale Ulrich. Lower half of the Lorraine. Common.
255. Cyclora minuta Hall. Lorraine and Richmond.
256. Cyclora parvula Hall. Richmond.
257. Cyclora pulcella Miller. Liberty.
258. *Cyrtolites dyeri* Hall. See Conradella dyeri.
259. *Cyrtolites inornatus* Hall. See Microceras inornatus.
260. *Cyrtolites magnus* Miller. See Oxydiscus magnus.
261. Cyrtolites ornatus Conrad. Lorraine and Richmond.
262. Helicotoma marginata Ulrich. Elkhorn.
263. Holopea hubbardi Miller. Saluda.

264. *Hormotoma bellicincta* (Hall). Not a Cincinnati group species.
265. Hormotoma gracilis (Hall). Utica. Probably does not occur in Indiana.
266. *Hormotoma trentonensis* Ulrich. Not a Cincinnati group species.
267. Hyolithes (?) dubius Miller and Faber. Richmond.
268. Hyolithes versaillesensis Miller and Faber. Richmond.
269. Liospira vitruvia (Billings). All divisions of the Cincinnati group.
270. Lophospira acuminata Ulrich. Middle Richmond.
271. Lophospira ampla Ulrich. Richmond.
272. Lophospira bicincta (Hall). Richmond.
273. Lophospira bowdeni (Safford). Lorraine.
273a. Lophospira hammeli (Miller). Saluda.
274. *Lophospira multigruma* (Miller). See Lophospira tropidophora.
275. Lophospira tropidophora (Meek). Whitewater.
276. *Lophospira ventricosa* (Hall). Not a Cincinnati group species.
277. Microceras inornatus Hall. Lorraine and Richmond.
278. *Murchisonia bellicincta* Hall. See Hormotoma bellicincta and H. trentonensis.
279. *Murchisonia gracilis* Hall. See Hormotoma gracilis.
280. *Murchisonia hammeli* Miller. See Lophospira hammeli.
281. *Murchisonia milleri* Hall. See Lophospira bicincta.
282. *Murchisonia multigruma* Miller. See Lophospira tropidophora.
283. *Murchisonia ventricosa* Hall. See Lophospira ventricosa.
284. Oxydiscus magnus (Miller). Richmond.
285. *Pleurotomaria subconica* Hall. See Clathrospira subconica.
286. *Pleurotomaria tropidophora* Meek. See Lophospira tropidophora.
287. *Protowarthia bilobatus* (Sowerby). Not an American species.
288. Protowarthia cancellata (Hall). Eden, Lorraine and Richmond.
289. Protowarthia subcompressa Ulrich. Lower Richmond.
290. Raphistoma richmondensis Ulrich. Middle Richmond.
291. *Salpingostoma expansa* (Hall). Not a Cincinnati group species.
292. Salpingostoma richmondensis Ulrich. Whitewater, upper part.
293. Schizolopha moorei Ulrich. Upper part of the Richmond. Whitewater.
294. *Tentaculites richmondensis* Miller. See Cornulites richmondensis.
295. *Tentaculites tenuistriatus* Meek and Worthen. See Cornulites tenuistriatus.
296. Trochonema madisonense Ulrich. Richmond.
297. Tryblidium indianense Miller. Richmond.
298. Tryblidium madisonense Miller. Richmond.

PELECYPODA.

299. Allonychia jamesi (Meek). Upper Lorraine.
300. *Ambonychia amygdalina* Hall. Not a Cincinnati group species.
301. *Ambonychia amygdaloidea*. See A. amygdalina Hall.
302. *Ambonychia bellistriata* Hall. Not found in the Cincinnati region. See Byssonychia radiata.
303. *Ambonychia carinata* (Goldfuss). Not an American species.
304. *Ambonychia costata* Meek. See Anomalodonta costata.
305. *Ambonychia jamesi* Meek. See Allonychia jamesi.

306. *Angellum cuneatum* Miller. See Cyrtodonta cuneata.
307. *Anodontopsis* (?) *milleri* Meek. See Orthodontiscus milleri.
308. *Anodontopsis* (?) *unionoides* Meek. See Ischyrodonta unionoides.
309. *Anomalodonta casei* Meek and Worthen. See Opisthoptera casei.
310. Anomalodonta costata Meek. Lower Richmond.
311. Anomalodonta gigantea Miller. Waynesville and Whitewater.
312. Byssonychia alveolata Ulrich. Upper Lorraine and lower Richmond.
313. Byssonychia grandis Ulrich. Lower Richmond, Whitewater (?).
314. Byssonychia obesa Ulrich. Whitewater.
315. Byssonychia praecursa Ulrich. Upper Lorraine.
316. Byssonychia radiata Hall. Eden, Lorraine and Richmond.
315. Byssonychia richmondensis Ulrich. Whitewater.
316. Byssonychia suberecta Ulrich. Lower and middle Richmond.
317. Byssonychia tenuistriata Ulrich. Richmond.
318. Clidophorus fabula Hall. Lorraine.
319. Clionychia excavata Ulrich. Richmond.
320. Ctenodonta cingulata Ulrich. Waynesville.
321. *Cycloconcha milleri* (Meek). See Orthodontiscus milleri.
322. Cymatonota typicalis Ulrich. Waynesville, Whitewater (?).
323. *Cypricardites sterlingensis* Meek and Worthen. See Whitella sterlingensis.
324. Cyrtodonta cuneata (Miller). Richmond.
325. Eridonychia crenata Ulrich. Whitewater (?), lower Richmond.
326. Ischyrodonta decipiens Ulrich. Whitewater.
327. Ischyrodonta elongata Ulrich. Middle Richmond.
328. Ischyrodonta miseneri Ulrich. Whitewater.
329. Ischyrodonta modioliformis Ulrich. Whitewater.
330. Ischyrodonta ovalis Ulrich. Middle Richmond.
331. Ischyrodonta truncata Ulrich. Middle Richmond.
332. Ischyrodonta unionoides (Meek). Lower Lorraine.
333. *Megaptera casei* Meek and Worthen. See Opisthoptera casei.
334. Modiolodon declivis Ulrich. Middle Richmond, Arnheim (?).
335. Modiolodon obtusus Ulrich. Lower Lorraine, Waynesville (?).
336. Modiolodon subovalis Ulrich. Richmond.
337. Modiolodon subrectus Ulrich. Richmond.
338. Modiolodon truncatus (Hall). Lorraine.
339. *Modiolopsis cincinnatiensis* Hall and Whitfield. See Whiteavesia cincinnatiensis.
340. Modiolopsis concentrica Hall and Whitfield. Waynesville.
341. *Modiolopsis modiolaris* Hall. See Modiolodon obtusus.
342. *Modiolopsis pholadiformis* Hall. See Whiteavesia pholadiformis.
343. Modiolopsis versaillesensis Miller. Waynesville (probably).
344. Opisthoptera casei (Meek and Worthen). Liberty, Whitewater, Elkhorn.
345. Opisthoptera obliqua Ulrich. Richmond.
346. Orthodesma canaliculatum Ulrich. Richmond.
347. *Orthodesma parallelum* (Hall). Not a Cincinnati group species.
348. Orthodesma rectum Hall and Whitfield. Lower Richmond.
349. Orthodesma subangulatum Ulrich. Richmond.
350. Orthodontiscus milleri Meek. Lower Richmond.

351. Ortonella hainesi (Miller). Whitewater.
352. Pterinea corrugata (James). Waynesville.
353. Pterinea demissa (Conrad). Lorraine and Richmond. A common fossil.
354. *Pterinea insueta* (Emmons). Very probably not a Cincinnati group species.
355. Rhitimya byrnesi Miller. Richmond.
356. Sedgwickia fragilis Meek. Lower Lorraine. May not occur in Indiana.
357. Sphenolium richmondense Miller. Middle Richmond.
358. Tellinomya hilli Miller. Saluda.
359. Whiteavesia cincinnatiensis (Hall and Whitfield). Lower Eden.
360. Whiteavesia pholadiformis (Hall). Richmond.
361. Whitella obliquata Ulrich. Lower Richmond.
362. *Whitella sterlingensis* (Meek and Worthen). Probably does not occur in Indiana.
363. Whitella umbonata Ulrich. Lower Richmond.

CEPHALOPODA.

364. Cyrtoceras amoenum Miller. Richmond.
365. *Cyrtoceras hallianum* d'Orbigny. Not a Cincinnati group species.
366. *Cyrtoceras lamellatum.* See C. lamellosum.
367. *Cyrtoceras lamellosum.* See C. hallianum.
368. Cyrtoeeras tenuiseptum Faber. Richmond.
369. Cyrtoceras thompsoni Miller. Upper Richmond (?).
370. *Endoceras approximatum* Hall. Not a Cincinnati species.
371. *Endoceras magniventrum* Hall. Not a Cincinnati species.
372. Endoceras proteiforme Hall. Throughout the Cincinnati group.
373. Gomphoceras indianensis Miller and Faber. Richmond.
374. Gyroceras baeri (Meek and Worthen). Middle Richmond.
375. *Ormoceras tenuifilum* Hall. Not a Cincinnati species.
376. Orthoceras bilineatum Hall. Richmond.
377. Orthoceras byrnesi Miller. Upper Lorraine.
378. Orthoceras carleyi Hall and Whitfield. Upper Lorraine (?).
379. Orthoceras duseri Hall and Whitfield. Lower Richmond.
380. Orthoceras gorbyi Miller. The horizon of this species is not known.
381. Orthoceras junceum Hall. Lower Eden. Probably does not occur in Indiana.
382. Orthoceras mohri Miller. Waynesville.
383. *Orthoceras spinale.* The identity of this species is not known. No such species is known from the Cincinnati group of Indiana.

CIRRIPEDIA.

384. *Plumulites jamesi* Meek. See Lepidocoleus jamesi.
385. *Turrilepas jamesi* (Meek). See Lepidocoleus jamesi.
385a. Lepidocoleus jamesi (Meek). Richmond. Probably also in the other divisions of the Cincinnati group.

Ostracoda.

386. *Beyrichia chambersi* Miller. See Ceratopsis chambersi.
387. *Beyrichia hammeli* Miller and Faber. See Ctenobolina ciliata hammeli.
388. *Beyrichia oculifera* Hall. See Ceratopsis oculifera.
389. *Beyrichia striato-marginata* Miller. See Eurichilina striato-marginata.
390. Bollia pumila Ulrich. Richmond.
391. Ceratopsis chambersi (Miller). Eden. Richmond (?).
392. Ceratopsis chambersi robusta. Ulrich. Lower Richmond.
393. Ceratopsis oculifera (Hall). Lorraine.
394. Ctenobolina ciliata hammeli (Miller and Dyer). Arnheim.
395. Entomis madisonensis Ulrich. Saluda.
396. Eurychilina striato-marginata Miller. Saluda.
397. Leperditia caecigina Miller. Saluda.
398. Primitia cincinnatiensis (Miller). Richmond.
399. Primitia impressa Ulrich. Waynesville (?).
400. *Strepula quadrilirata simplex* Ulrich. See Tetradella quadrilirata simplex.
401. Tetradella quadrilirata (Hall and Whitfield). Lower Richmond.
402. Tetradella quadrilirata simplex Ulrich. Richmond.

Trilobita.

403. Acidaspis ceralepta (Anthony). Eden.
404. Acidaspis cincinnatiensis Meek. Eden, Lorraine.
405. Acidaspis crosotus James. Eden.
406. Calymmene callicephala Green. Eden, Lorraine and Richmond. A common fossil.
407. Ceraurus icarus (Billings). Whitewater.
408. Ceraurus pleurexanthemus Green. Lower Lorraine and base of Waynesville.
409. Dalmanites breviceps Hall. Waynesville.
410. Dalmanites callicephalus (Hall). Probably not found in the Cincinnati group.
411. Isotelus maximus Locke. Rather common in all divisions of the Cincinnati group.
412. *Isotelus gigas.* See I. maximus.
413. *Phacops callicephalus.* See Dalmanites callicephalus.
414. *Phacops gallicephalus.* See P. callicephalus.
415. Proetus spurlocki Meek. Lower Lorraine.
416. Trinucleus concentricus Eaton. Lower Eden.

Annelida.

417. *Conchiolites conica.* See Cornulites flexuosus Hall.
418. Cornulites flexuosus (Hall). Throughout the Cincinnati group.
419. *Ortonia minuta.* See Cornulites minor.
420. Cornulites minor (Nicholson). Lower Lorraine.
421. Cornulites richmondensis (Miller). Waynesville.
422. Cornulites tenuistriatus (Meek and Worthen). Richmond.

SPONGES AND CORALS.

DIAGNOSES OF GENERA.

BEATRICEA Billings.

Cylindrical or angulated stems, often fluted and ranging in size to over ten feet in length and a foot in diameter. A central tube with cystose tabulae and a peripheral vesicular structure characterize the fossil. (Grabau).

CALAPOECIA Billings.

Corallum massive or branching. Corallites prismatic, polygonal, generally hexagonal. Tabulae numerous. Numerous short, well marked septa. Mural pores large, disposed in vertical rows between the septa. (Zittel).

COLUMNARIA Goldfuss.

Corallum massive, hemispheric, pyriform or irregularly spheroidal. Often of large size. Composed of prismatic or polygonal corallites, which radiate outward from the base of attachment. Walls of corallites not excessively thickened, and contiguous: corallites in contact throughout, except sometimes near their mouths. Walls imperforate. Septa well developed and lamellar, extending from the top to the bottom of the visceral chamber, not quite reaching to the center of the tube. A long and short series alternate with each other. Tabulae very numerous and well developed, complete and nearly horizontal, not placed at corresponding levels in contiguous tubes. (Nicholson.)

LABECHIA Milne-Edwards and Haime.

Corallum a laminar expansion, attached by a portion of the base, the remainder of the lower surface covered by a concentrically striated epitheca. Upper surface with rounded or elongate, solid tubercles, separated by an imperforate calcareous membrane. Internal structure consisting of a great number of cylindrical calcareous columns directed vertically upward from the basal epitheca, their upper ends forming the surface tubercles. Interspaces between the columns occupied by a series of lenticular vesicles with their convexities directed upward. (Nicholson.)

PROTAREA Milne-Edwards and Haime.

Encrusting. Cells simple, polygonal. Small sharp points at the angles of most of the calices. Calices shallow. Septa less trabecular than in most of the *Poritidae*. Toothed at the margin; the teeth nearest the center simulating a small columella. No pali. (Edwards and Haime.)

STREPTELASMA Hall.

Turbinate, often curved. Septa numerous, alternately long and short; the free edges of the longer septa twisted together in the center to form a pseudocolumella. Tabulae few or absent. Position of the principal septum is recognizable on the exterior by a system of pinnately diverging costal ridges. (Zittel.)

TETRADIUM Dana.

"*Coralla aggregata, tubulis cellisque quadrangulatis composita, septis parietibusve tenuissimis; cellis lamellis angustis* 4 *stellatis.*

"Coralla massive, consisting of 4-sided tubes, and cells with very thin septa or parietes; cells stellate, with 4 narrow lamellae.

"This genus is near Receptaculites, but differs in having very thin parietes, and four distinct rays within the cells, one to each side. The species answering to the description, is a fossil of uncertain locality, in the collections of Yale College, New Haven. The cells are about half a line in breadth. The name, from the Greek τετρας, *four,* alludes to the quadrate structure."—Dana, Zoophytes of the Wilkes Exploring Expedition, 1846, p. 701.

DESCRIPTION OF SPECIES.

BEATRICEA NODULOSA Billings.

Plate I, figs. 1a, 1b.

Beatricea nodulosa Billings, 1856. Geol. Surv. Canada, Rep. Progress for 1856 (1857), p. 344.

"*Description.*—The surface of this species is covered with oblong, oval, subtriangular projections from one to three lines in height, each terminating in a rounded blunt point which is nearer to one end of the prominence than the other. Some of the projections are six or seven lines in length at the base, and half as wide. Generally they are smaller, and often with a nearly circular base; the distance between them is from one to three lines. They exhibit in some specimens a tendency to an arrangement in rows following the length of the stem. In some instances these rows wind around the stem in spirals. In addition to these characters, the whole surface is fretted with minute points, and these when partially worn show a perforation in the centres.

"In a specimen three inches in diameter, the diameter of the central tube is three-quarters of an inch; the transverse septa are thin, very concave, and at distances from each other varying from one line to one inch.

"*Locality and formation.*—Anticosti, at Wreck Point, Salmon River and Battery Cliff. Lower Silurian."—Billings, *loc. cit.*

Saluda formation in Indiana.

BEATRICEA UNDULATA Billings.

Plate I, fig. 1.

Beatricea undulata Billings, 1856. Geol. Surv. Canada, Rep. Progress, for 1856 (1857), p. 344.

"*Description.*—The surface of this species is sulcated longitudinally by short, irregular, wave-like furrows from two lines to one inch across, according to the size of the specimen. In other respects it appears like *B. nodulosa.* The largest specimen is ten feet five inches in length, about eight inches in diameter at the large end, and six inches and a-half at the smaller extremity. Another short fragment is fourteen inches in diameter.

"All the specimens of both species are replaced by carbonate of lime, but show more or less perfectly the septate character of the central tube and the concentric arrangement of the layers of the stem. They are generally broken up into short pieces.

"*Locality and formation.*—Cape James, Table Head, two miles east of Gamache Bay, and numerous other localities in the Middle Silurian."—Billings, *loc. cit.*

Saluda formation in Indiana.

CALAPOECIA CRIBRIFORMIS (Nicholson).

Plate I, figs. 3-3b; Plate V, fig. 1.

Columnopora cribriformis Nicholson, 1874, Geol. Mag., N. S. decade II, vol. I, p. 253, fig. 1.

"*Spec. Char.*—Corallites for the most part hexagonal or pentagonal, averaging about one line and a half in diameter, sometimes more or less. Septa in the form of strong vertical ridges, from twenty to twenty-four in number, equally developed, never reaching the centre, or extending more than quite a short distance into the interior of the corallite. Between each pair of septa is a row of large oval or circular mural pores, so that there are from twenty to twenty-four rows of these openings in each corallite, generally about four on each face. Not only are the rows of pores thus extraordinarily numerous, but the pores are of unusually large size, and are placed close together, about three of them occupying the space of one line measured either vertically or transversely. The walls of the corallites thus assume a completely cribriform appearance, and look as if composed of a series of vertical pillars (the septa) united by horizontal cross-bars. Tabulae, in the specimens observed, imperfect, from three to four in one line.

"At first sight, especially when viewed from above, *Columnopora cribriformis* presents a striking resemblance to *Columnaria alveolata,* Goldfuss; the shape and size of the corallites being alike in both species. The specimens of *Columnaria alveolata* which are found in the Trenton limestone, so far as I have seen, have, also, short septa, in the form of strong ridges, which extend inwards for a very small distance; and this still further increases the resemblance just spoken of. In the latter species, however, the walls of the corallites are compact, and are not perforated by pores, and this of itself is a sufficient point of distinction. On the other hand, *Columnopora cribriformis* is distinguished from all the massive species of *Favosites,* both by the well-marked septa and by the large size and enormous number of the mural pores. From *Michelinia, C. cribriformis* is separated by the fact that the tabulae are certainly not vesicular, whilst the pores are much larger and more closely set than in any species of the former genus, and the septal system is at the same time much better developed. In the only specimens I have seen, the tabulae of *C. cribriformis* are poorly preserved, and nothing is left of them except their bases. This state of things, however, is quite commonly observable in specimens of *Columnaria* and *Favosites;* and I entertain no doubt but that the tabulae of the present form were really complete and in all respects well developed."—Nicholson, *loc. cit.*

This species is reported by Nicholson from the Cincinnati group, near Cincinnati, Ohio.

Nicholson has shown the calices in his figure, reproduced in this report, as considerably smaller than in the fine specimen which I figure. He says, however, in his description that in the size of the corallites the species does not differ from *Columnaria alveolata,* and in giving the dimensions of the corallites in another place he allows some latitude in this respect. The large specimen figured by me was found loose at Richmond, Indiana. I have also seen a small specimen from the Liberty formation on Tanner's Creek, Indiana, and another in the base of the Saluda on Cedar creek, near Versailles, Indiana. (1.34A15a.)

COLUMNARIA ALVEOLATA Goldfuss.

Plate I, figs. 4, 4a.

Columnaria alveolata Goldfuss, 1826, Petrefacta Germaniae, p. 72, pl. xxiv, figs. 7 a-c.=*Favistella stellata* Hall.

"*Columnaria hemispherica, tubis e basi radiantibus inaequalibus longitudinaliter striatis, lamellis stellarum remotis e centro radiantibus et marginalibus alternis.—Petrefactum calcarem e calcareo transitorio Americae septentrionalis.*"—Goldfuss. (The above description is taken from the second edition of the Petrefacta, 1862).

This is the form commonly known in the Ohio valley region as *Favistella stellata* Hall (1847) and shown by Nicholson to be the true *Columnaria alveolata* Goldfuss.*

Nicholson's very excellent description of *C. alveolata* is as follows:

"*Spec. Char.*—Corallum massive, subhemispheric, or pyriform, often attaining a very considerable size. Corallites prismatic, hexagonal or pentagonal, but often more or less drawn out along one axis, the larger ones being from rather less than two to over three lines in their long diameter, and having numerous smaller tubes interspersed amongst them. Walls of the corallites more or less amalgamated, the line of division between contiguous tubes still remaining quite distinct. Mural pores apparently wanting. Septa unequally developed, alternately large and small, the latter quite rudimentary, and the former extending usually across two-thirds of the distance between the wall and the axis of the visceral chamber, or even reaching the last-mentioned point. The septa are thin and flexuous, but completely lamellar, and the number of each series varies from about twelve to fifteen or more. Tabulae complete, horizontal, or somewhat flexuous, about six in the space of two lines. Calices polygonal, unequally-sized, moderately deep, with thin margins, usually closely contiguous, but sometimes sep-

*The form described by Hall from the Black River formation of New York as *C. alveolata* Goldfuss is not that species, and has been renamed *C. halli* by Nicholson, Paleozoic Tabulate Corals, 1879, p. 200.

arated by slight interspaces; the floor formed by the uppermost tabula, the surface of which is striated by the radiating septa.''—Nicholson, Paleozoic Tabulate Corals, 1879, p. 195, pl. x, figs. 1, 1a.

In the Richmond formation of Indiana this species marks one of the most persistent zones in the whole formation, namely the base of the Madison beds or Saluda formation (Foerste). Here the characteristic hemispherical heads occur in great numbers. The bed of the creek along the old right-of-way east of Osgood, is one of the best localities known to the writer, although they may be found in abundance at and about Madison. Between Versailles and Madison for a considerable interval, this coral is very rare, and its place seems to be taken by a very large species of *Tetradium.*

LABECHIA MONTIFERA Ulrich.

Plate I, figs. 2-2b.

Labechia montifera Ulrich, 1886, Contributions to American Paleontology, p. 33, pl. ii, figs. 9, 9a.

''This species forms large crusts, rarely more than 5 mm. in thickness, upon foreign bodies. (Usually species of *Orthoceras.*) The surface is undulating and elevated at intervals of 6 mm., more or less, into large conical monticules, the slopes of which are marked by irregularly intermittent, radiating ridges; the intervening spaces between the monticules is covered quite uniformly by numerous unequal small granular eminences, of which about ten occur in 5 mm.; sections prove these to be the projecting ends of vertical pillars. In transverse sections * * * the pillars are of an irregularly stellate form; their size is variable, but those occupying the monticules are always the largest. The intermediate spaces are crossed by a variable number of faint, curved lines, representing the cut edges of lenticular vesicles which occupy the space between the pillars. In vertical sections * * * the pillars are seen to be rather unequal, and separated from each other by a loosely-woven vesicular tissue. The vesicles vary much in size, but are disposed to arrange themselves in obscure layers.

''It is possible that this species ought not to be considered as congeneric with *L. conferta,* E. and H. (the type of the genus) as the differences between them may be of greater importance than I now believe them to be. In transverse sections of *L. conferta,* the vertical pillars appear as simple, round columns, and look quite different from the irregularly stellate section presented by the pillars of *L. montifera.* Another but less important difference is found in the different habits of growth. Thus *L. montifera* is an encrusting form, while *L. conferta* grows into free laminar expansions, covered on the lower side by a concentrically striated epitheca. Another species, forming masses as much as one foot in length, is not uncommon in the upper part of the Cincinnati group at Clarksville, O., and other localities. Specimens of *L. montifera* are rather rare at the same horizon. The specimen figured was collected at Madison, Indiana."—Ulrich, *loc. cit.*

I have seen a number of good specimens of this species in the upper part of the Richmond formation (Saluda) in the vicinity of Osgood, Indiana. One very fine specimen, completely covering the conch of an *Orthoceras,* firmly imbedded in the rock of a creek bed about four miles northeast of that place, was seen, at a horizon a little below the base of the Saluda. The other specimens seen were about twelve feet above the base of the Saluda. Ulrich does not give the horizon of the type, but doubtless it came from a similar level.

PROTAREA VETUSTA Hall.

Plate I, fig. 5.

Porites ? vetusta Hall, 1847, Pal. New York, vol. I, p. 71, pl. xxv, figs. 5 a-b.

"A subhemispheric coral, composed of irregular concentric laminae; cells vertical to the laminae; openings upon the surface, nearly circular, with internal vertical lamellae which reach half way to the centre.

"To some extent, this specimen presents the character of PORITES, in a great degree of perfection. The surface of the specimen being weathered, the radiating lamellae are often obliterated. The centre of the cells are also destitute (perhaps from weathering) of the fine elevated points characteristic of some recent species of PORITES.

"This is the only species known to me in the lower term of our system, which presents, in any degree of perfection, the characters of recent PORITES."—Hall, *loc. cit.*

The diameter of the calices of Hall's species is not stated in the above description. As measured on his figure in the Paleontology of New York, the average is rather less than a millimetre. In the specimen figured by me the diameter of the calices averages rather over one millimetre, in many instances one and one-half. The diameter of the calices of *P. verneuili* E. and H. is stated to be about three millimetres. No figure of the latter is given, and the description is very meagre, but the size of the calices would seem to me to preclude the possibility of our species being the same. Whether the common Richmond form is to be referred to Hall's species or not, does not seem to me to be a question to decide on the basis of so slight a variation in the size of the calices as I have indicated above. It can be settled only by a careful comparison of the Richmond and Trenton forms point by point. For the present, therefore, I prefer to refer the Richmond form, as has heretofore been done, to the species *P. vetusta.*

1.34A13a, 13b, 14a, 16, 17, 18, 19, 20, 22....1.41A4, 6, 7, 8, C1, 2, 3, D1, 2, 3, E1, 2, 3, 4, 5....1.12F3.

A study of these localities shows that the species is restricted to the Liberty and Whitewater divisions of the Richmond formation.

STREPHOCHETUS RICHMONDENSIS Miller.

Plate II, figs. 3-3b.

Stromatocerium richmondense Miller, 1882, Jour. Cincinnati Soc. Nat. Hist., vol. v, p. 41, pl. ii, fig. 1-1b.

"This is a small, globular or spheroidal sponge, consisting of numerous, irregularly concentric, more or less wrinkled, calcareous laminae, separated by interlaminar spaces, filled with minute cortical tubes. It is destitute of the larger orifices and canals that usually occur in *Stromatopora,* and I have been unable to ascertain that the concentric laminae are perforated by canals; they are apparently more dense than the intervening spaces, but it is not supposed that they constituted a barrier to the circulation. The sponge appears to consist of minute tubes radiating from a central point, in all directions; these are cut short by a laminar covering, which forms a basis for the minute radiating tubes to spread in all directions, from its outer surface, until they are likewise arrested by another covering, which, in turn, forms the basis for radiating tubes, and so on to the 10th or 15th covering. These coverings appear in cut and weathered specimens as irregularly concentric laminae. In magnified sections it shows an apparent vesicular structure, but no spicules have been determined. I have referred the species to *Stromatocerium* because it agrees with that genus in its general texture, and seems to be destitute of the larger canals and superficial openings that characterize the genus *Stromatopora.*

"It occurs in great abundance, in some of the rocky strata, in the upper part of the Hudson River group, at Richmond, Ind.

Dr. John T. Plummer, in a communication to the *American Journal of Science,* many years ago, called the specimens 'pisolitic balls embedded in the solid rock.' He said these pisolitic strata vary from two to ten feet in depth, and are frequently found blended with the marlite. However, I did not find them in such massive strata, but there are some layers of rock about three or four inches in thickness, largely made up of specimens of this little sponge, that may be found on the high ground immediately above the railroad bridge, in the northern part of the city. It is found at other places, in that locality, and may be regarded as a common species." —Miller, *loc. cit.*

This species occurs at Richmond in the upper part of the Whitewater division.

STREPTELASMA DIVARICANS Nicholson.

Plate I, figs. 6, 6a.

Palaeophyllum divaricans Nicholson, 1875, Pal. Ohio, II, p. 220 pl. xxii, figs. 10, 10b.

"Corallum usually free, sometimes apparently attached, compound, formed of conical, turbinate corallites, which are produced by lateral gemmation, or rarely by fission, and which are directed outward from the parent, usually at a more or less open angle, and are never in actual contact with one another [?]. The number of corallites in the corallum, so far as observed, varies from two to six. Septa from fifty-eight to sixty-two, alternately large and small, the large ones becoming twisted as they approach the center of the visceral chamber, where they unite with one another laterally, and form a more or less developed central mass of vesicular tissue [pseudocolumella]. No dissepiments or columella. Tabulae unknown. Wall with a well-developed epitheca, with longitudinal ridges corresponding with the septa within, and also with faint encircling striae and a few shallow annulations of growth. Calice deep, with a flattened space at the bottom. Free edges of the septa not furnished with spines or denticulations. Apparently no fossette.

"The best preserved specimen which came under my notice consists of two corallites, one budded from the side of the other at nearly right angles. The largest corallite has a length of nearly ten lines, a diameter of calice of seven lines, and a depth of calice of four lines. Another specimen consists of six nearly equally sized corallites, apparently produced by parietal gemmation, and having a length of five or six lines, and a diameter at the calice of about five lines. Another specimen consists of two large corallites which appear to have been produced by fission, being attached only by their pointed bases, and being nearly in contact with one another. The length of the largest of these corallites is more than an inch and a half, and its diameter at the calice is ten lines. Another specimen, precisely similar in its mode of growth, is attached to the dorsal valve of *Rhynchonella dentata,* Hall, the length of the largest corallite being only three lines, and the diameter of the calice the same.

"The specimens from which the above description was taken in most respects closely resemble *Streptelasma corniculum,* Hall, especially as concerns their twisted septa; but they possess a much smaller number of septa (if specimens of the same size be compared), and they are always rendered composite by the production of lateral buds or by cleavage.

"With *Palaeophyllum rugosum,* Billings, the present species cannot be confounded for a moment, the former constituting large masses of scarcely separate corallites, which vary from one to six lines in diameter." Nicholson, *loc. cit.*

The types are said to be from the Cincinnati group, Cincinnati, Ohio. This is certainly in error. The species is strictly a Richmond form, and I have not seen it except in the upper part of the latter formation. In the Whitewater division at Richmond it is common, and at other localities where beds of this age are exposed I have collected the species, especially in the vicinity of Laurel, Indiana. It is quite constantly associated with *Rhynchotrema dentata.* In the description above, the fact is mentioned that one of the specimens was attached to the valve of *R. dentata.* This species may accordingly be taken as one of the markers of the Whitewater division of the Richmond formation. Its range is by no means as great as that of *Streptelasma rusticum.*

1.41A4, 5, 6, 7, 8, C2-3, D1, 2, 3, E4, 5, 6 and the localities mentioned above. I have a number of specimens from Tanner's Creek that are probably referable to this species. They come from the upper part of the Liberty formation.

STREPTELASMA RUSTICUM (Billings).

Plate II, figs. 2-2b.

Petraia rustica Billings, 1858, Geological Survey of Canada, Report of Progress for 1857, p. 168 (not figured).

"*Description.*—Straight or slightly curved, covered with a strong epitheca, which is more or less annulated with broad, shallow undulations; radiating septa about one hundred or usually a little more; much confused in the centre, where they form a vesicular mass [pseudocolumella]; every alternate septum much smaller than the others, only half the whole number reaching the centre. Length from two inches and a half to three inches and a half. Diameter of cup one inch to one inch and a half; depth of cup half an inch or somewhat more.

"This species appears to be the same as that described by Edwards and Haime under the name of *Streptelasma corniculum.* The true *S. corniculum* of Mr. Hall is a very different species, being always shorter and much curved."—Billings, *loc. cit.*

This species is reported by Billings from the Hudson River (Cincinnati) group of Canada; and there is very little doubt that it is specifically identical with the very common form of the Richmond of Indiana and Ohio. Several other species of *Streptelasma* have from time to time been reported as occurring in the Cincinnati rocks, but it seems certain that aside from *S. divaricans* this is the only species to be accredited to these rocks in the Cincinnati region.

This species has ordinarily been reported as occurring throughout the Richmond formation, but I have not found it in the Waynesville or Arnheim members of that formation. It is especially characteristic of the Liberty and Whitewater divisions. It is generally absent in the Saluda and Elkhorn divisions.

1.34A11, 12, 13a, 14a, 15a, 15b, 16, 17, 18, 19, 20, 21.... 1.41A4, 5, 6, 7, 8....1.41D1, 2, 3....1.41C1, 2-3....1.41E1, 2, 3, 4, 5, 6....1.12D1-6, E3, F3.

TETRADIUM MINUS Safford.

Plate II, figs. 1-1c.

Tetradium minus Safford, 1838, Am. Jour. Sci., 2d ser., vol. XXII, p. 238. (Not figured.)

"We include in this species massive specimens (generally small), the tubes of which are only from one-fourth to one-third of a line in breadth. The tubes in some specimens are quite regular, in others, though generally four-sided, are more or less irregular and have the aspect on the upper surface of Chaetetes. Lamellae as in T. fibratum."—Safford, *loc. cit.*

The specimens of this species seen in the Richmond formation are often of great size, one measured by the writer being nearly five feet in diameter. It characterizes very strictly the Saluda division of the Richmond, and is especially abundant and persistent at the base of this division, where it is often associated with *Columnaria alveolata.*

ECHINODERMATA.

DIAGNOSES OF GENERA.

ANOMALOCRINUS Meek and Worthen.

Revised by Wachsmuth and Springer.

General form depressed, calyx comparatively large, rather shallow, subglobose; arrangement of plates extremely irregular, scarcely two plates being of equal size. Basals five, small, subequal, partly hidden by the column. Radials irregular, all differing in size and form, simple or compound, sometimes divided vertically. The left antero-dorsal radial is compound, composed of two pieces; that of the opposite side and the anterior radial are simple. The left postero-lateral radial is the largest plate in the calyx, and either simple or bisected vertically, composed of two nearly equal parts. The lower segment of the left antero-lateral is subquadrangular, the angle along the baso-radial suture being so obtuse as to form almost a straight line; upper side truncate and slightly convex. The upper segment is irregularly hexagonal, truncate above and below, much wider at the lower than the upper side, widest across the lateral angles. The two together have almost the dimensions of the single radials, but, in place of being wider than high, they are higher than wide, with a narrow concavity for the reception of the brachials. The fifth radial—the right postero-lateral one—rests against the truncate upper side of a large azygous plate, and as this stands in line with, and has nearly the form and proportions of the lower section of the compound radial, and the radial plate the form of its upper segment, the two appear in the specimen as forming jointly another compound radial.

There is also among the rays a great diversity in the number of brachials, and this gives to the specimen that abnormal, irregular outline which is so characteristic of the genus. Some of the rays have two, others three brachials, while the right posterior ray has generally four or more.

Arms long, bifurcating at regular intervals, widely divergent, rather stout at their origin; tapering upward. They are composed of a succession of rather long, quadrangular pieces, interrupted only by the axillaries which are pentangular, and which divide the main arm, and each division of the arm, into two equal parts. The pinnules are slender, composed of long pieces, given off from every arm joint, but at one side only in succession—not alternately—until the next bifurcation of the arm, when on both divisions they all change to the opposite side. By this arrangement there are always 8 to 10 pinnules in succession, first on one side, then on the other. The first pinnule occurs on the second arm plate, not on the first, but every succeeding plate is pinnulated with the exception of the bifurcating ones. The proximal pinnule after each bifurcation is considerably heavier and longer, almost arm-like, and bifurcating, the others are simple. The arm furrows are shallow but wide, only one side having sockets for the reception of pinnules.

The ventral sac is tubular, and rests upon the left side of the posterior radial as in the Heterocrinidae. The proximal plate of the tube is large, subquadrangular, and is succeeded by other apparently large pieces. Of the plates on the ventral side little is known.

Column very large, almost circular, pentapartite, highly ornamented; central canal large, star-shaped, the projections located interradially. The structure of the column along the axial canal resembles that of *Barycrinus,* and *Vasocrinus,* with which *Anomalocrinus* agrees also in the form of the calyx. (Wachsmuth and Springer.)

DENDROCRINUS Hall.

General form of the crinoid elongate and slender. Calyx obconical, higher than wide, unsymmetrical. Underbasals five, similar in form, scarcely of medium size, but extending beyond the column. Basals five, the largest plates in the calyx; four of them equal, hexagonal, the fifth or posterior one heptagonal, truncate above for the support of a large anal plate. Radials alternating with the basals all around, simple in four of the rays, pentagonal and of about equal size. The right posterior radial is compound, divided by a horizontal suture into two halves, which taken together, have about the form of the simple plates, only slightly longer. Brachials two to five, some long and narrow and others short and wide. Anals one, subquadrangular. Arms long, branching; ambulacral furrow deep. Pinnulae wanting. Dome unknown. Ventral sac strongly developed, composed of numerous small, hexagonal, alternately interlocking plates of equal size, strengthened by little transverse or slightly oblique costae, and so arranged as to present an ascending zigzag appearance. Column pentagonal, or, exceptionally, round. (Wachsmuth and Springer.)

ECTENOCRINUS Miller.

General form very elongate; calyx small subcylindrical, moderately expanding; basals five, unequal; radials irregular, four plates in three series, before the bifurcation of the free arms, and three in each of the other two series; arms ten, long; pinnules strong; azygous plates three, following each other, but not in a direct line; vault unknown; column very long, round, tripartite, and attaching by an expanding base. This genus is founded upon *Heterocrinus simplex* Hall, as the type, because the genus *Heterocrinus* was founded upon *H. heterodactylus* as the type, which is quite widely removed from *H. simplex.* (Miller.)

GLYPTOCRINUS Hall.

Calyx obconical or subglobose; plates thin, often highly ornamented; the fixed brachials passing imperceptibly into arm plates, and the interbrachials into disk plates; the arms rising vertically from the edge of the tegmen. Basals five, of uniform size, forming a small cup. Radials and costals of nearly equal size; the second costal hexagonal. Distichals varying in number, there being but two in species in which palmars take part in the calyx; but when the second bifurcation takes place in the free arms, they are quite numerous, frequently six to eight or more in the calyx, followed by several others in the free arms. When this is the case, the second distichal gives off a large pinnule; while in the other the proximal pinnule is developed into an arm. Arms rarely branching beyond the second bifurcation, rising vertically from the calyx; they are long, slender, rounded on the back, and composed of a single series of short, slightly wedge-shaped pieces, which do not interlock. Pinnules slender, closely arranged; the proximal ones the stoutest, and frequently incorporated into the calyx. Interbrachials definitely arranged; the first large, resting upon the sloping upper faces of the radials; there being two plates in the second row, and two, sometimes three, in the higher ones. The anal side widest, having generally three plates in the second and all succeeding rows. Interdistichal spaces large, composed of numerous small plates; some species also having interpalmars. Ventral disk depressed-hemispherical, very slightly extending above the level of the arm bases; the ambulacra subtegminal, except near the periphery, where some of the small covering pieces are exposed, but the course of the ambulacra is indicated by surface ridges. Plates of the disk very minute and irregularly arranged, decreasing in size toward the arms. The arrangement of the larger plates at the summit is also irregular, being unlike that of orals, which probably are not represented. Column round; axial canal large, pentalobate, the lobes directed interradially, except in one species in which the stem is pentangular and the central canal radially disposed. (Wachsmuth and Springer.)

HETEROCRINUS Hall.

Redefined by Wachsmuth and Springer.

Calyx small, subcylindrical, tapering but slightly from the column upward. Basals five, more or less unequal, without underbasals; the so-called underbasals of Meek representing the upper stem joint. Radials very irregular, and varying among the rays in number as well as in size. There are two segments in the two antero-lateral rays, while the three remaining rays have but one, this, however, nearly as large as the two in the other rays. The two plates at the right posterolateral side consist of the azygous piece—the lower one—and of the radial, which upon its upper side supports the brachials, giving off laterally a small ventral tube. Arms ten, composed of single joints, alternately united by syzygy, with strong pinnules from every second joint. Column tripartite, almost circular; axial canal large, pentalobate, the lobes directed interradially. (Wachsmuth and Springer.)

IOCRINUS Hall.

General appearance somewhat similar to *Pentacrinus*; comparatively larger than *Heterocrinus*; arms longer and more frequently bifurcating; calyx more broadly spreading, and perfectly symmetrical up to the top of the radials, giving the form of a short, inverted, pentagonal pyramid with the five sides deeply concave. Underbasals undeveloped. Basals small, pentagonal. Radials comparatively large, strong, all pentagonal, and of the same height; their upper margins truncated for nearly their entire breadth for the junction of the succeeding pieces. Brachials three to four in each ray, the upper one auxiliary, and supporting the first free divisions of the arms. In the right posterior ray there is interposed between the true brachials and radial plate a pentagonal bifurcating piece, which is evidently free and movable like the brachials, and of the same width. This peculiar plate, which is truly radial, supports on its right sloping side the usual number of brachials, and on the left a row of quadrangular plates vertically arranged, extending to the tips of the arms, and forming the posterior wall of a large ventral tube. In external appearance these plates resemble the brachials and arm plates, only they are somewhat higher and not quite as wide; they are gibbous, and form an elevated ridge, which causes this appendage to resemble an arm or a branch of the ray, and so it was considered by Hall in his description of *Heterocrinus polyxo*. Both sides of the mesial ridge are indented to accommodate other plates, of which there are two to each median plate, one abutting against the middle part, and the other opposite the suture. These lateral plates are delicate, three or four times wider than high, and, like the other, longitudinally arranged. Each of them contains a rather deep furrow, which in perfect specimens is arched over by a row of wedge-shaped plates which stand out prominently and appear very much like pinnulae. Arms bifurcating frequently, gradually tapering; arm pieces like the free radials, all projecting at the upper edge, thereby producing a sort of imbrication. Pinnulae unknown. Column strong, distinctly pentagonal, the angles in line with the radial plates of the body. (Wachsmuth and Springer.)

LEPADOCRINUS Conrad.

Body oblong or ovoid, consisting of four series of plates; first series four; second series five; third series four; fourth series five; pectinated rhombs three to five; arms three or four, recumbent, and consisting of a double series of interlocking plates, resting in shallow grooves; plates poriferous, column tapering. (Miller.)

LICHENOCRINUS Hall.

"Bodies parasitic on shells and other foreign substances. Form discoid or depressed-convex, with a proboscidiform appendage rising from the center. Disc composed of an indefinite number of polygonal plates, and apparently having no distinct mode of arrangement. Proboscis perforate, and in the known species formed of five ranges of short plates alternating and interlocking at their margins. The fossils for which this generic name is proposed are small parasitic scab-like bodies, usually found adhering to the smooth surfaces of shells and other foreign substances." (Hall, original diagnosis.)

PALAEASTER Hall.

Stellate, disc small; two ranges of plates in each ambulacral groove, and two on either side, adambulacral and marginal; four ranges of pores in each groove; oral plates in pairs at the base of the rays; dorsal plates polygonal, sometimes spinous, madreporic tubercle. (Miller.)

PALAEASTERINA McCoy.

Pentagonal, depressed, with plated disc that fills up the angles, leaving the rays but slightly produced; ambulacra shallow, bordered by subquadrate plates. (Miller.)

TAENIASTER Billings.

No disc or marginal plates; rays long, flexible, spinous; adambulacral plates elongated; two rows of ambulacral pores; ossicles contracted in the middle. (Miller.)

XENOCRINUS Miller.

Basals four, forming a low cup, which is decagonal at the upper end; five of its sides supporting the five radials, the five others the interradials and anal plates. This arrangement gives to the basals, owing to their abnormal number, a very irregular form, no two of the plates being alike. Radials generally a little larger than the costals. Costals two, the sides bending abruptly inward and forming highly elevated ridges; the distichals to about the fifth or eighth plate form part of the calyx. The lower of these plates are larger, and more or less resemble the costals, while the upper ones are more like free arm plates. Arms ten, simple, rather stout; composed of very short cuneiform pieces, which at the tips of the arms slightly interlock. Interradial spaces deeply impressed; composed of numerous minute pieces without definite arrangement; they rest upon the basals, separating the rays from their bases up. Anal interradius wider than the four others; divided longitudinally by a row of folded plates, which like the radials have a prominent ridge upon the outer surface, and a groove at the inner floor. The ridge ends in a small protuberance containing the anal opening, which points upwards. Interdistichal spaces also deeply depressed, and filled by irregular, minute plates, which, like those between the main rays, pass imperceptibly into the disc. Ventral disc comparatively flat, composed throughout of very small pieces; orals being unrepresented, and the disc ambulacra subtegminal. Column quadrangular, with pentangular central canal, the angles of which are directed interradially. (Wachsmuth and Springer.)

DESCRIPTION OF SPECIES.

ANOMALOCRINUS INCURVUS (Meek and Worthen).

Plate III, figs. 1-1c.

Heterocrinus ? (*Anomalocrinus*) *incurvus* Meek and Worthen, 1865, Proc. Acad. Nat. Sci. Philadelphia, p. 148.

"Body expanding rapidly from the base to the summit of the first and second radial pieces, where it is more than twice as wide as high; composed of the five basal, five first radial, and two second radial pieces. Basal pieces pentagonal, of moderate size, wider than long, and forming together a low, rapidly-expanding, pentagonal cup. First radial pieces in three of the rays from three to five times as large as the basal pieces, wider than long, two hexagonal and one heptagonal—all with their superior lateral angles strongly incurved between the arms, and each with a strong protuberant, rounded facet above, for the reception of the small succeeding radials. In the remaining two rays, the first pieces are smaller and lower than those of the others, and each pentagonal in form, with the upper side horizontally truncated its entire breadth, for the reception of a larger second radial, which in these two rays agrees in size and form, as well as in being included as a part of the walls of the body, with the large first pieces of the other rays. Succeeding radials not more than one-third as wide as those included in the walls of the cup, and forming small, rounded, widely separated free arms, consisting of one to three quadrangular and one pentagonal pieces to each ray. Arms above the first bifurcation on the second or third pentagonal free radial, in two of the rays seen, bifurcating again on the third piece, and, in one instance, sending off nearly at right angles from the second piece after the first division, a strong tentacle, or small lateral branch.

"First anal piece pentagonal, longer than wide, and resting between the left sloping side of a large second primary radial and the right sloping side of a first primary radial, with rather less than half its length projecting above the former, and without extending down so as to bring its base in contact with any of the other plates below. In the individual examined, this piece is strongly incurved, and supports on its inner truncated end an oblong, narrow second anal, which in its turn supports a smaller third piece, all of which are arranged in a right line, and probably form one side of a proboscis.

"Surface smooth, or only with traces of fine granules. Sutures a little concave. Column comparatively strong and rounded near the base, where it is composed of short joints, and marked with obscure, regular longitudinal striae.

"Height of body on the anal side, 0.28 inch; do. on the opposite side, 0.22 inch; greatest breadth above (allowing for a slight accidental compression) about 0.38 inch; breadth of free arms at their connection with the body, 0.08 inch; breadth of column at its connection with the base, 0.16 inch.

"This species presents points of analogy both to *Heterocrinus,* Hall, and *Hybocrinus,* Billings, and yet seems to differ from both to such an extent that if we could be sure some of its peculiarities are not abnormal in our specimen we would be inclined to view it as the type of a new genus. As we have seen but the one specimen, however, which is not complete in all its parts, we have concluded to place it, for the present at least, as the type of a subgenus under *Heterocrinus.* It differs from the typical species of that genus in having the column round instead of pentagonal, and in having only the first primary radial pieces in three of the rays, and two in each of the others, included as a part of the walls of the body; while its preceding primary radicals are very narrow, and form small, rounded, distinctly separated arms, instead of being nearly as wide as those soldered in the walls of the cup. Another peculiarity is the strongly incurved superior lateral angles of the large radial pieces around the margin of the cup between the arms.

"In the rather unsymmetrical form of the body, the slender proportions of the free arms, and its general aspect, it resembles *Hybocrinus,* from which it differs in having but one anal piece connected with the walls of the cup, and in having two of the rays and two of the primary pieces included in the wall, while its free arms bifurcate twice or oftener, instead of being simple from their origin."—Meek and Worthen, *loc. cit.*

The type is from the "upper part of the Cincinnati group" at Cincinnati, Ohio.

1.12E3 (?).

DENDROCRINUS CASEI Meek.

Plate IV, figs. 2-2b.

Dendrocrinus casei Meek, 1871, Amer. Jour. Sci., 3d ser., II, p. 295 (not figured).

"Column very distinctly pentagonal, the angles at the connection with the body being continuous with strong ridges passing up the sutures between the basal pieces and to the middle of the subradials. Body pentagonal-obconic, a little wider above than high. Base wider than high, strongly pentagonal, being deeply excavated up the middle of each piece, and very prominent at the lateral sutures; basal pieces wider below than high, pentagonal in form, with the mesial angle above salient, and the superior lateral sloping sides much longer than the lateral. Subradial pieces of moderate size, those seen, hexagonal in form, and all very convex in the middle, from which point they send one strongly elevated ridge to meet others on each of the surrounding plates, and others coming up the sutures between the basals, while on each side of all these ridges, excepting sometimes those passing to the first radials above, there is usually a smaller, less elevated ridge; the surface of the body being thus divided by these ridges into very profoundly excavated triangular spaces, in the middle of which the corners of the body plates meet. First radial pieces, excepting one of the anal side, larger than the subradials, about as wide as high, with a general pentagonal outline, the upper side being longest and deeply excavated for the reception of the comparatively narrow free radials or arm pieces; one on the right of the anal series, shorter than the others, pentagonal in form, and supporting above another larger radial that is included as a part of the wall of the body, and corresponds with the first radials in the other rays, excepting that it is shorter; all convex and sending a strong ridge to each of the contiguous body plates below, while a number of much smaller ridges pass horizontally across from one to another of these pieces on each side. Arms or free rays comparatively rather narrow, distinctly rounded on the outer or dorsal side, and composed of transversely oblong pieces that are about twice as wide as long below the first bifurcation; in the first ray on the right of the anal series, bifurcating on the fourth free piece, beyond which they are seen to be long and composed of proportionally narrow pieces; but their mode of bifurcation, if they divide again, and their structure in the other rays, cannot be made out from the specimens at hand. Anal series unknown.

"Ventral extension of the body more than four times as long as the latter, and as seen flattened by pressure, of greater breadth; as usual, composed of numerous small equal, hexagonal, alternately interlocking pieces, that are strengthened by little oblique costae so arranged as to present an ascending zigzag appearance. Surface, excepting the strong costae of the body plates, and the smaller ones of the ventral part, without ornamentation.

"Height of body to top of first radials, 0.39 inch, greatest breadth at top, 0.32 inch. Length of incomplete ventral extension, 1.95 inch; breadth of same as flattened, near upper end, 0.65 inch; breadth of arms below the first bifurcation, 0.12 inch.

"This beautiful species seems to be a true *Dendrocrinus,* as it can be seen to have two of the primary radials on the right of the anal series, included as a part of the walls of the body, while all its other parts seem to conform to the structure of that group. The differences between *Dendrocrinus* and *Poteriocrinites* are not very great, and it is thought by some that the former should stand only as a subgenus under *Poteriocrinites.* If so, the name of this species when written in full would be *Poteriocrinites* (*Dendrocrinus*) *casei.* In general appearance it resembles *Palaeocrinus angulatus* of Billings, but it differs in having the costae of its body, in part, with a smaller one on each side; while its column is very much more strongly pentagonal. Of course, it also differs in the generic character of having its ventral part extended upward nearly or quite as long as the arms.

"It may be that the species here described is the same figured by Mr. Christy, in his 'Letters on Geology,' as a Pentacrinite (without a specific name), as it came from the same horizon, and from about the same region of the country. It does not, however, agree *exactly* with his figures in details.

"The specific name is given in honor of L. B. Case, Esq., of Richmond, Indiana, to whom I am indebted for the use of the finest specimen of it I have seen. I am also under obligations to C. B. Dyer, Esq., of Cincinnati, for the use of two smaller, and nearly as good specimens. Figures of the species, with a full description, will be given in the Ohio Geological Report."—Meek, *loc. cit.*

The type is from the Richmond formation at Richmond, Indiana. It has also been found near Oxford, Ohio.

DENDROCRINUS POLYDACTYLUS (Shumard).

Homocrinus polydactylus Shumard, Trans. St. Louis Academy of Science, vol. I, 1857, p. 78.

I have not been able to obtain a copy of part I of the first volume of the Transactions of the St. Louis Academy of Science, and therefore am unable to quote the original description.

A fragment of a considerable portion of the base of the calyx of this rather common species was found at Madison (1.12F3). I reproduce herewith Meek's very excellent figure of the species from the Ohio Paleontology.

ECTENOCRINUS SIMPLEX (Hall).

Plate IV, figs. 10, 10a.

Heterocrinus simplex Hall, 1847, Pal. New York, I, p. 280, pl. lxxvi, figs. 2 a-d.

"Body slender, very gradually expanding above the base, and composed of five regular divisions above the pelvic plates; pelvic plates five, four of them irregularly pentagonal, and one with the lateral and upper margins equal; costal plates in two of the divisions single, hexagonal, and supported on the straight upper edges of the pelvic plates, those of the three other divisions double, the lower one pentagonal with the lateral margins short, the second one quadrangular; scapular plates quadrangular, with the upper sides concave and supporting a pentagonal arm-joint; arm-joint supporting on its oblique upper edges a double series of obliquely quadrangular or rhomboidal plates, which gradually diminish in size; column subpentagonal, composed (near the pelvis) of alternating thicker and thinner plates.

"This species is readily identified by its structure, which is peculiar in the form of four of its pelvic plates, and the double or subdivided costal plates in three of the divisions; the body and arms, when closed together, present a slender subcylindrical form, scarcely attracting attention, from their resemblance to a collection of small individual columns. The small fragment of a column attached, which is crushed, can scarcely be characterized, but it is clearly pentagonal."—Hall, *loc. cit.*

The types are from the Lorraine, at Cincinnati, Ohio. The species is reported in Kindle's list from Madison, Indiana. Probably it does not occur there.

GLYPTOCRINUS DECADACTYLUS Hall.

Plate IV, fig. 9.

Glyptocrinus decadactylus Hall, 1847, Pal. New York, I, p. 281, pl. lxvii, figs. 1 a-f; pl. lxxviii, figs. 1 a-u.

"Body cupshaped, with ten arms, which support twenty tentaculated fingers; plates all marked by strong elevated radiating ridges; pelvic plates five, pentagonal, supporting upon their upper oblique edges five heptagonal costal plates, which are succeeded by five hexagonal second costals in a direct line; scapular plates heptagonal, resting directly upon the straight upper side of the second costals, and supporting on their two upper oblique edges two hexagonal arm-joints, which in turn support a second arm-joint, and this one two hexagonal hand-joints, the latter sustaining the fingers; fingers composed of a column of fimbriated joints, which are quadrangular below and cuneiform above; column round or obtusely pentagonal, varying in its character at different distances from the body.

"In addition to the regular series of plates supporting the arms and fingers, there are numerous intermediate ones, of which a hexagonal intercostal plate, a first pair of hexagonal interscapular plates, and a second pair of heptagonal interscapular plates, the latter truncated above, are always regular and uniform. Between these last interscapular plates there is usually an irregular interscapular joint, and several pectoral plates. The number and arrangement of the latter does not appear to be always uniform; but I have not been able to find specimens where every part could be satisfactorily examined. Between each pair of arms there are three or more plates, and between each pair of fingers one or more plates at the base. The capital plates, and their arrangement, are shown in the enlarged figure of the crown, fig. 1 *d,* pl. 77. [Pal. N. Y. vol. I.] The mouth is depressed and obscure.

"The body of this species is readily recognized by the strong radiating ridges which mark the surface of all the plates below the tentaculated fingers. The surface is also marked by five more prominent ridges, which, proceeding from the first costal plates, bifurcate on the scapular plate, the divisions extending to the base of each pair of fingers. In these characters of the surface, and in its general structure, it resembles some the species of the Genus ACTINOCRINUS, from which it differs in having five instead of three pelvic plates. There is some difficulty in making out the entire structure, since the plates usually adhere very closely, and some of the pectoral and interbrachial plates are very small. The important parts, however, and the plates proceeding to the arms, are readily and clearly determined.

"This fossil is usually found destitute of the column; and I have not been able to decide satisfactorily whether all the fragments found with it are parts of the same, or belong to two species. The first, which evidently belong to this species, and form the upper part of the column, consist of joints, having a small base resting upon the broader disc of the next one below, giving more freedom of motion. Other portions have the upper surface of the disc excavated, and the column appears to be composed of a series of cups, alternating in size and placed one within the other, having the upper edges either smooth or fimbriated. These columns have usually a distinct round alimentary canal, with the upper and lower surface marked by fine rays, more deeply impressed near the edge. In other parts of the column, where the plates are more nearly equal in size, the upper and lower surfaces have a pentapetalous impression or elevation radiating from the alimentary canal. This character, in fine, becomes the prominent and characteristic one of the greater proportion of the fragments of columns which we find; and they present all the variety of broad equal smooth joints with even surfaces, or of similar joints with a thin plate interposed, and of columns composed of moniliform joints with smaller ones between; or of distant rounded joints, sometimes deviating slightly from a cylindrical form."—Hall, *loc. cit.*

Column round, with large pentalobate axial canal; the nodal joints a little the widest. The supposed infrabasals of this species are really the upper stem joint. (Wachsmuth and Springer.)

The probable presence of this species is indicated at a number of localities by the characteristic segments of the column. I have seen no calices, however, and therefore have not entered the species in any of my faunal lists.

GLYPTOCRINUS DYERI Meek.

Plate IV, fig. 8.

Glyptocrinus dyeri Meek, 1872, Proc. Acad. Nat. Sci. Philadelphia, p. 314.

"Body globular-subturbinate, being wider than high, with sides rounding under to the base. Sub-basal pieces obsolete, or, if present, not exposed externally. Basal pieces (subradials of some) very small, and projecting as a thin rim below, much wider than high, and presenting a trigonal general outline, though the lateral angles are doubtless minutely truncated. First radial pieces of moderate size, heptagonal in form, and wider than long; second and third a little smaller, the second being hexagonal, and the third pentagonal, and supporting on its superior sloping sides the first divisions of the rays. Secondary radial or supraradial series each composed of from eight to eleven pieces, rapidly diminishing in length upward to the second bifurcation or commencement of the arms, just below which a few of the smaller pieces seem to be free and bear pinnulae on their inner sides; farther down, the second and fourth secondary radials of each ray give off, alternately on each side, small divisions that do not become free, but are soldered into the interradial walls, though they can be traced to the summit of the body, where they merely give origin to pinnules.

"Anal area a little wider than the interradial areas. First anal plate of about the same size as the first radials, hexagonal in form, and supporting in the next range three pieces, arranged with the middle one higher than the others; while above these, three smaller pieces can be seen arranged in the same way in the third range, and three to four or five in the fourth, which is as far up as they can be traced. The middle plates of this series form a direct vertical row, that have a rather prominent mesial, rounded ridge extending all the way up from the middle of the lowest piece, of about the same size as those passing up the primary and secondary radial series, while the other plates on each side and other parts of the lowest pieces are ornamented with radiating costae of smaller size, like those on the interradial pieces.

"Interradial areas not excavated below, but becoming moderately concave above; first interradial pieces of about the size of the second primary radials, hexagonal in form, and supporting two other somewhat smaller pieces in the next range, that bear between their superior sloping sides a fourth smaller piece, while above these there are two pieces in the next range that connect with the pieces of the little lateral divisions of the secondary radials, and perhaps some other small intercalated pieces filling the upper part of the interradial areas.

"Axillary areas flat, and each occupied below by a hexagonal or heptagonal piece of about the size of the second piece of each secondary radial, while the space above is occupied by several much smaller pieces.

Arms four to each ray, rounded on the dorsal sides, slender, of moderate length, very gradually tapering, simple, and composed of very short, slightly wedge-formed pieces, each of which bears a pinnule at its larger inner lateral end; pinnules slender, rather closely arranged, deeply furrowed on the inner side, and apparently composed of rather long joints.

"Surface of body plates all ornamented with distinct radiating costae, starting from the center of each piece, and passing one to each of its sides so as to connect with others on each contiguous piece; of these costae, those passing up the middle of each of the radial series are a little larger and more prominent than those of the interradial plates, while they bifurcate with the rays so as to send a division up each of the secondary radial series, toward the upper part of which they become more prominent and rounded, being there of about the size of the free arms. Column unknown.

"Height of body, 0.60 inch; breadth, about 0.68 inch; length of arms, 1.05 inch; thickness of same, 0.05 inch; number of joints, in a space of 0.10 inch near the base, eight.

"This beautiful species reminds one, by its sculpturing, of the common typical species *G. decadactylus,* from which, however, it may be at once distinguished by its proportionally broader and shorter body, with sides rounding regularly under to the column instead of being obconical. It also has proportionally more slender arms, and differs materially in having, in each secondary radial series, from nine to eleven pieces between the first bifurcation of each ray and the arm bases, instead of only two. In the form of its body, it agrees more nearly with *G. ornatus* of Billings; but it differs materially from that species in having twenty arms instead of only ten, as well as in less important details.

"The specific name is given in honor of Mr. C. B. Dyer, of Cincinnati, Ohio, to whom I am indebted for the use of the very fine specimens from which the description was made out."—Meek, *loc. cit.*

Column round; the nodal joints somewhat larger; the axial canal pentalobate, and moderately large. (Wachsmuth and Springer.)

The type is from about 100 feet below the tops of the Hills at Cincinnati, Ohio. The species is reported in Kindle's list from Madison, Indiana.

HETEROCRINUS HETERODACTYLUS Hall.

Plate III, figs. 5, 5a.

Heterocrinus heterodactylus Hall, 1847, Paleontology of New York, vol. I, p. 279, pl. lxxvi, figs. 1 a-c.

"Body short, rounded, subcylindrical, tapering above and below; pelvis composed of five small pentagonal plates, which are succeeded by the same number of larger costal plates, and these again by five scapulars; arms irregularly subdivided; column pentagonal, composed of thick joints, which are nodulose at the angles; joints alternating in size as they approach the pelvis.

"This is a peculiar species, remarkable for the small size of the body when compared with the column. The irregularity of the arrangement of the plates in the arms and fingers is likewise a striking characteristics of the species, which is constant in two specimens from different localities. In one of the arms, the scapular plate supports a regular series of six or more plates of similar form without division. The arms at the right and left of this one are again unlike each other. The one on the left has three regular and gradually diminishing joints above the scapular, and of the same form; the last one supports the cuneiform joint, which again supports a double row of joints (or a pair of fingers). The arm on the right of the first mentioned, consists of a pair of quadrangular joints, each of which supports a cuneiform joint. In the remaining two arms, no plates have been traced beyond the scapulars, and consequently the entire form of the species cannot be determined. Sufficient is visible, however, to show the irregular character of the arms, from which its name is given."—Hall, *loc. cit.*

Reported by Hall from the Hudson River group (Cincinnati series) of New York and Ohio. To this species I have referred segments of the column of a common crinoid from many localities in the Utica and Lorraine. As I have seen no complete specimens of the species I have not listed it in the faunas of the various sections.

HETEROCRINUS JUVENIS Hall.

Plate III, figs. 3-3b.

Heterocrinus juvenis Hall, 1866, 24th Rep. New York State Museum, p. 212, pl. 5, figs. 9, 10. (Advance sheets.)

"Body minute, the greatest diameter of the cup not exceeding a line, and the height from the base to the top of the first arm plates a line and a half.

"Basal plates appearing only as triangular points at the lower lateral angles of the adjacent subradials. Subradial plates wider than high, hexagonal. Three of the first radial plates higher than wide, each supporting a single smaller arm plate, which presents the appearance of having had another plate above; the other two radial plates are short, quadrangular; one of them supporting a small plate above, and the other one a wedge-form plate, upon which rest two other small plates, one larger than the other; the largest of these has the position and appearance of an anal plate.

"Surface of plates smooth.

"Column distinctly pentangular, nearly as large as the diameter of the calyx, composed of alternating thick and thin plates.

"This crinoid may be only the young of some previously described species; but as there have been several individuals found, all presenting the same characters and of about the same size, I have thought proper to designate it as a distinct species for the present."—Hall, *loc. cit.*

The type is from the upper part of the Cincinnati group at Lebanon, Ohio.

IOCRINUS SUBCRASSUS (Meek and Worthen).

Plate IV, figs. 7, 7a.

Heterocrinus subcrassus Meek and Worthen, 1865, Proc. Acad. Nat. Sci. Philadelphia, p. 148. (Not figured.)

"This species agrees so nearly with the last [*Heterocrinus crassus*] in most of its characters as to render a detailed description unnecessary. It will be readily distinguished, however, by its smaller size, as well as its less robust appearance, and the different aspect of its arms. This latter difference consists in the more slender appearance of all the divisions, and particularly in the joints of which they are composed having their upper margins projecting beyond the base of each succeeding piece above, so as to present a kind of upward imbricating appearance and roughness, not seen in the arms of *H. crassus.*

"As in the last, its rays bifurcate first on the fifth and sixth pieces, and one of them gives off a branch (?) on the left side of the second radial, above which it bifurcates regularly on the sixth piece. After the first regular division on the last radial piece, some of the arms are seen to divide again on the fourth, others on the fifth, and others on the sixth pieces, after which one division is known to bifurcate on the sixth piece, and still again on the thirteenth.

"Breadth of body at the summit of the first radial pieces, 0.27 inch; height of do., 0.13 inch; length of rays from top of first radial pieces to the first bifurcation, 0.21 inch; entire length of arms from first division to extremities, about 1.50 inch. Breadth of column at its connection with the base, 0.15 inch."—Meek and Worthen, *loc. cit.*

The type is from the "upper part of the Cincinnati group" at Cincinnati, Ohio. Reported from Madison, Indiana, by W. T. S, Cornett. Probably does not occur there.

LEPADOCRINUS MOOREI (Meek).

Plate IV, figs. 6-6b.

Lepocrinites moorei Meek, 1871, Amer. Jour. Sci., 3d ser., II, p. 296. (Not figured.) (= *Lepadocystis moorei.*)

"Body obovate. Base forming nearly one-fourth the height of the body, its four pieces being about as wide as long, of nearly equal size, and irregularly pentagonal in form, excepting one on the anal side, which is hexagonal. The five pieces of the second range of irregular form and size, two on the anal side being longer than wide, and extending up to form the lower margin of the principal opening, which is moderately large, and placed about one-third the length of the body below the top. Arrangement of the plates above not clearly made out. Pectinated rhombs four, comparatively large, one situated at the suture between one of the basal pieces and the contiguous piece of the next range above, on the anterior side of the body; another on the side to the left of the opening, and arranged with its longer axis directed transversely, on a line with the opening, while the other two are nearly on a line with the right side of the opening, on three plates that corner together, the arrangement being such that their longer axes diverge at right angles upward; in these, 15 to 20 of the little bars may be counted.

"Recumbent arms short, or confined mainly to the upper side, or extending down nearly to the opening on the anal side, another to the two rhombs to the right of the opening, a third to that on the left, and the fourth to the anterior side, the direction of all being thus nearly or quite at right angles to each other. Column thick at the base of the body, but tapering rapidly below; as usual, composed of very thin pieces. Surface of body plates marked by distinct radiating lines.

"Height of body, 0.46 inch; breadth, about 0.36 inch; thickness of column at its connection with the base, 0.14 inch.

"This species seems to agree well with the genus *Lepocrinites* of Conrad, excepting in the very unusual character of having four rhombs instead of only three. As one of these, however, seems to be merely rudimentary, or in other words, not perforated by little slits, I can scarcely think its presence a generic character.

"I believe this is the first example of this group of *Cystideans* that has been found in the Lower Silurian, in this country. It occurs, however, in the upper part of the lower series, where some of the other fossils begin to resemble Upper Silurian types.

"It has been proposed to correct the orthography of Mr. Conrad's genus to *Lepadocrinus,* and if this orthography should be adopted, the name of our species would be written *Lepadocrinus* or *Lepadocrinites Moorei.* The most usual custom, however, has been to retain the original orthography of generic names in such cases."—Meek, *loc. cit.*

The type is from the Richmond formation at Richmond, Indiana.

LEPIDODISCUS FABREI (Miller).

Plate IV, fig. 11.

Agelacrinus faberi Miller, 1894, Jour. Cin. Soc. Nat. Hist., XVII, p. 156, pl. viii, figs. 24, 25.

"This species is founded upon a single specimen, that is very much broken up and attached to the valve of an *Orthis occidentalis.* It is about the size of an average *Agelacrinus cincinnatiensis.* The body is circular, depressed planoconvex, and composed of numerous squamiform plates that imbricate inward from the periphery toward the center. The larger plates occur in the rim that surrounds the extremities of the arms. The arms are much broken up in our specimen, but there seem to be four sinistral and one dextral, composed of interlocking plates, as is usual in this genus. The surface of all the plates is densely and beautifully tuberculated.

"This species is distinguished from all others, in rocks of the same age, by the tuberculated plates. It is also distinguished from *Agelacrinus cincinnatiensis* and *A. pileus* by the absence of the great number of small plates that form the periphery in those species, and also by having the larger plates of the body, in the rim, that surrounds the ends of the rays.

"Found by Mr. C. L. Faber, in whose honor the specific name is proposed, in the extreme upper part of the Hudson River Group, about half way between Osgood and Versailles, Indiana, and now in his collection."—Miller, *loc. cit.*

LICHENOCRINUS CRATERIFORMIS Hall.

Plate IV, figs. 12-12b, Plate III, fig. 2.

Lichenocrinus crateriformis Hall, 1866, 24th Rep. New York State Museum (Advance sheets), p. 217, pl. vii, fig. 7.

"Body small, distinctly subpentagonal, subdiscoid, with an elevated margin and strongly depressed center; composed of medium-sized polygonal plates. Proboscis minute, central.

"This species differs from the preceding [*L. dyeri*] in its more elevated margin, and in the absence of the five prominences of the disc; the proboscis is much smaller in proportion to the size of the body, and the whole is composed of a smaller number of larger sized plates."—Hall, *loc. cit.*

1.12E3 (?).

LICHENOCRINUS DYERI Hall.

Plate IV, fig. 5.

Lichenocrinus dyeri Hall, 1866, 24th Rep. New York State Museum (Advance sheets), p. 216, pl. vii, figs. 1-6.

"Body small, discoid, depressed in the middle, with five slight elevations midway between the center and the edge of the disc. Proboscis strong, composed of short plates. Disc composed of very small polygonal plates. Surface smooth."—Hall, *loc. cit.*

A more adequate description of this species is given by Meek in the Ohio Paleontology, as follows:

"Body depressed-discoidal, nearly circular, or obscurely pentagonal in outline; composed of a great number of very small, slightly convex, nearly or quite smooth pieces, of very unequal size and form, the larger ones often somewhat longer than wide, with their longer diameters directed inward and outward; central depression small; column-like appendage comparatively stout at its basal, or attached end, where it is sub-pentagonal, or nearly round, and composed of about five or six ranges of very short, distinctly and regularly interlocking pieces; perforation at base pentagonal, and scarcely equalling one-third the diameter of the appendage at that point. Interior unknown.

"Diameter of an apparently adult individual, 0.32 inch; convexity about 0.09 inch; thickness of column-like appendage, at its connection with the body, 0.08 inch; length unknown."

The type is from the top of the hills at Cincinnati.

Reported in Kindle's list from Ripley County, Indiana.

LICHENOCRINUS PATTERSONI Miller.

Plate IV, figs. 4, 4a.

Lichenocrinus pattersoni Miller, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 118, pl. x, figs. 6, 6a.

"Body robust, round or sub-circular, plano-convex, with a depression around the column, composed of numerous plates of unequal size, having no regular geometrical form, and disposed without any definite order of arrangement. If the plates, in the specimen illustrated, could be arranged, in regular concentric series, there would be, about eighteen ranges, between the column and the circumference.

"The plates are smooth.

"The column-like appendage is large, round and composed, as in other species, of five ranges of thin plates.

"The plates, in this species, are as large as the plates in *L. crateriformis,* and as numerous as in *L. dyeri,* but they have neither the arrangement nor form of either."—Miller, *loc. cit.*

According to Miller this species probably occurs at Versailles, Indiana, "in the upper part of the Hudson River Group."

LICHENOCRINUS TUBERCULATUS Miller.

Plate IV, fig. 3.

Lichenocrinus tuberculatus Miller, 1874, Cin. Quar. Jour. Sci., I, p. 346, fig. 38.

"Body discoidal, circular in outline; lower surface, or surface of attachment, flat, or conforming to the surface to which it is attached; upper surface strongly convex or subhemispheric, with a deep circular depression in the central part, around the column; upper surface of body composed of numerous, irregularly arranged, thin, pentagonal or hexagonal plates, nearly uniform in size, smooth on the under side and highly convex or tuberculated on the outer surface. Excluding the plates immediately surrounding the column, within the central depression, which are much smaller than the others, the remainder will number about one hundred. Interior filled with upright lamelliform plates, radiating from a central point, on which the exterior plates appear to repose. Column pentagonal, length unknown.

"Diameter of a medium-sized specimen 3/12 inch, convexity 1/12 inch; but Mrs. M. P. Haines, of Richmond, Indiana, to whom I am indebted for the specimen engraved, informs me that she has recently found specimens varying from 1/12 to 6/12 of an inch in diameter.

"It is distinguished from *L. crateriformis,* which species it most resembles, by its tuberculated plates. It differs, too, in its greater convexity, more abrupt central depression, and greater uniformity in the size of its plates.

It is found in the vicinity of Richmond, Indiana, in the upper part of the Cincinnati Group. Small specimens, very closely resembling this species in general outline, are found near Clarksville, in Clinton County, Ohio, but differing, in the specimens examined, in this important regard, that the plates appear to be smooth instead of tuberculated."—Miller, *loc. cit.*

PALAEASTERINA SPECIOSA Miller and Dyer.

Plate III, fig. 8.

Palaeasterina speciosa Miller and Dyer, 1878, Jour. Cin. Soc. Nat. Hist., I, p. 30, pl. i, fig. 7.

"Pentagonal; rays obtuse at their apices; greatest distance from point to point about 2 1/2 inches; breadth of body between rays about 1 1/3 inches, and distance from tip of ray to next adjoining tip on either side about 1 1/2 inches.

"The marginal plates are small and somewhat hemispherical, near the termination of the rays, they gradually enlarge and become square, and then rectangular as they approach the disc, until at the narrowest part of the disc or body of the fossil they are twice as long as wide. There are about 50 marginal plates between the apex of one ray and the next one adjoining, or in a perfect specimen of this size about 250.

"The back or dorsal side is covered with numerous plates (probably in a complete specimen of this size there would be 1,000 or more), which are very prominent in the center or somewhat conical, and seem to have been joined together with deeply serrated edges. The plates have from three to eight of these indentations, which give them a beautiful star-like appearance.

"The ambulacral grooves are narrow and deep, as shown by the sharp ridges on the back of the specimen. The small dorsal plates which cover the ambulacral pieces are exfoliated in some places, and show two rows of ambulacral plates coming evenly together, and forming the sharp ridge."—Miller and Dyer, *loc. cit.*

Reported by Kindle from Richmond, Indiana, on the authority of James.

URASTERELLA GRANDIS Meek.

Plate III, figs. 6-6b.

Stenaster grandis Meek, 1872, Amer. Jour. Sci., 3d ser., III, p. 258. (Not figured.)

"Attaining a very large size, with the body or disc comparatively small, or only of the breadth of the united inner ends of the five rays. Rays long, slender, gradually tapering, and very flexible, widest at their immediate connection with the body, where they seem to be more or less depressed, but becoming more nearly terete farther out. Dorsal side of body and arms composed of numerous subtrigonal pieces that rise into pointed tubercles, or sometimes assume almost the character of short spinules, and are arranged in quincunx, so as to form about eight rows near the middle of the rays; those of the outer two rows being a little larger than the others. Dorsal pores apparently rather large, and passing through between the concave sides of contiguous pieces. Ventral side of body unknown. That of the rays composed of the usual single row of transverse ambulacral pieces on each side of the well defined, rather deep, and moderately wide ambulacral furrows. Adambulacral pieces rather more than twice as long as wide, with their longer diameters at right angles to the ambulacral furrows, and rounding over from end to end so as to be most prominent in the middle; while they do not connect with each other by flat sides, but have little projecting processes, and corresponding sinuses, apparently for the purpose of imparting greater flexibility to the rays.

"Breadth of body, 0.63 inch; length of rays, 2.40 inches; breadth of same at their connections with the body, 0.36 inch. Diameter across from the tips of rays on opposite sides, about 5.50 inches.

"Not having seen the under side of the body of this species, I am not quite sure that it is exactly congeneric with Mr. Billings's typical species of *Stenaster*. It does not show the peculiar contraction of the inner ends of the rays, seen in his *S. Salteri*, from which it also differs in a marked degree in the much greater length and slenderness of its rays. In these characters, however, it agrees more nearly with his *S. pulchellus* and *S. Huxleyi*; though it differs from the first specifically in having proportionally larger rays, with more numerous dorsal pieces, and in attaining a much larger size. I had suspected that it might possibly be the *S. Huxleyi*, but on comparing drawings, and the foregoing description, sent to him for that purpose, with his typical specimen of *S. Huxleyi*, Mr. Billings writes that he has no doubt whatever that it is entirely distinct.

"The specimen shows a few short spines connected with the adambulacral pieces; but neither their exact mode of attachment, nor their arrangement, can be very clearly made out. They seem, however, to connect with these pieces along their joining edges, instead of springing from their crests.

"Adopting the suggestion already made by another, that the name *Stenaster* for this group should be replaced by McCoy's name *Urastrella,* previously suggested, incidentally, for apparently congeneric forms, the name of the species here described would become *Urastrella grandis.*"—Meek, *loc. cit.*

The type of this species is from the Richmond formation at Richmond, Indiana.

TAENIASTER GRANULIFERUS (Meek).

Plate III, fig. 7.

Protaster ? granuliferus Meek, 1872, Amer. Jour. Sci., 3d ser., IV, p. 274. (Not figured.)

"Disc small, apparently circular; rays rather slender, and of unknown length. Dorsal surface of disc and rays covered by an integument composed of innumerable minute grains of calcareous matter. Ventral side of disc not well exposed in the specimen but apparently provided, in the interradial spaces, with minute spines directed outward. Oral pieces not well exposed in the specimen. Arm-pieces regularly alternating, but apparently rectangular at their inner ends, and not interlocking along the minute mesial impressed line, longer transversely than in the direction of the length of the rays; each largely excavated at its anterior outer end so as to form a large pore, or pore-like depression, and divided transversely by a furrow into two parts, the anterior one of which is very short, and the posterior longer and marked by a minute pit at its inner end; about eight or nine of these pieces in each range of each ray included within the margin of the disc. Outer arm-pieces (adambulacral of some) smaller than those of the inner ranges, and placed edge upward, with an oblique outward direction so as to imbricate outward or toward the extremities of the rays; each bearing one or more minute articulating spines.

"Breadth of disc, about 0.43 inch; breadth of arms at their inner ends, 0.10 inch.

"The only specimen I have seen that is certainly known to belong to this species is very imperfect, being merely an incomplete disc, and the inner ends of the rays. It does not conform to the characters of *Protaster* given in Prof. Forbes's diagnosis, in all respects, since its disk, especially on the upper side, is covered by an integument composed of a vast number of very minute grains of calcareous matter, instead of distinct imbricating scales. It is therefore not improbable that perfect specimens would show other characters that would warrant the establishment of a new genus or sub-genus for such forms, in which case the name *Alepi-*

daster might be applied to the group, which would probably also include *Protaster gregarius* of Meek and Worthen.

"I have intentionally avoided, in the foregoing description, the use of the terms ambulacral and adambulacral pieces, applied by some in describing the arms of species of *Protaster* and similar forms, because it seems doubtful whether these terms can be properly applicable to such types. I should certainly think not, *if these types belong to the Ophiuroidea* (in which no ambulacral furrows exist) instead of to the *Asteriodea.* According to Dr. Wright, however, *Protaster Miltoni* of Salter has a well developed madreporiform body, and hence would belong to the *Asteroidea.* Yet it is very curious that these types seem to have no proper ambulacral canals, and we have apparently no positive evidence that the viscera of the animal were not confined to the disc, as in the *Ophiuroidea.*"—Meek, *loc. cit.*

The type of this species is from the Richmond formation at Moores Hill, Indiana.

XENOCRINUS BAERI (Meek).

Plate IV, figs. 1, 1a.

Glyptocrinus baeri Meek, 1872, Amer. Jour. Sci., 3d ser., III, p. 260. (Not figured.)

"Body of about medium size, globose-obconoidal. Sub-basal pieces apparently not developed, or very small. Basal pieces short and pentagonal. First primary radials of comparatively moderate size, presenting a general pentagonal outline; second a little narrower than the first, but of nearly the same length, with a general heptagonal outline; third a little narrower than the first, but of nearly the same length, with a general pentagonal form. Secondary radials, consisting of about four pieces in succession, on each upper sloping side of each third primary radial; the first two or three of each series only about one-third smaller than the second primary radials, while above these the succeeding pieces soon become much shorter free brachials. Interradial pieces numerous, small, of very unequal size, and without any regularity of arrangement. Anal series unknown, but probably consisting of a mesial series of hexagonal pieces resting one upon another, and a greater number of much smaller pieces irregularly arranged on each side. Axillary spaces each occupied by some six or more very small pieces.

"Arms ten, rather long, simple, widest a little above their bases, and thence gradually tapering to their ends; composed of very short pieces, so strongly cuneiform as to appear almost to taper to nothing alternately on opposite sides, while each supports a pinnule at its thicker end, along the inner margins. Pinnules very long, moderately short, nearly in contact, and composed of pieces three to four times as long as wide. Surface of body plates without costae or striae; those of the primary and secondary radial series more prominent than the much smaller pieces filling the interradial spaces, and thus forming somewhat flattened ridges, more or less interrupted at the sutures, and abruptly beveled at the sides; interradial and axillary areas roughened by a minute projecting central point on each of the little pieces filling them.

"Column of moderate thickness, apparently nearly round, or perhaps subpentagonal near the base, and composed of alternately thicker and thinner pieces, the former of which project a little beyond the others.

"The body of the only specimens of this species I have seen, are too much distorted by pressure to afford accurate measurements, but it seems to have been about 0.45 inch in height, by a little less in breadth; while its arms measure 0.07 inch in breadth at the widest part, a little above the top of the body, where about eight arm pieces may be counted in a length of the same extent.

"This species will be readily distinguished from all of the described forms of the genus, resembling it in other respects, by having only ten simple arms, and by the large number and small size of its interradial pieces. In the latter character it resembles *G. nealli*, of Hall, from which, however, it differs materially in almost every other respect, but more particularly in having only ten instead of twenty arms, which are also stouter. Its interradial and axillary spaces likewise differ materially in not being distinctly excavated, and in having each of the little pieces by which they are filled provided with a little projecting point.

"The specific name is given in honor of Dr. O. P. Baer, of Richmond, Indiana, to whom I am indebted for the use of the specimens from which the description has been prepared."—Meek, *loc. cit.*

Lower arm joints rectangular. Anal side divided by a longitudinal row of anal plates, shaped like the radials and costals. Column quadrangular, with obtuse angles; the joints extended outward into long knife-like edges. (Wachsmuth and Springer.)

The type is from the Richmond formation at Richmond, Indiana.

BRYOZOA.

METHODS OF STUDY.

The Trepostomatous Bryozoa require, as indicated in the introduction, certain special methods of study. A few of the more common and characteristic forms may readily be recognized in the field without special preparation, but for the greater number, and for all forms, if the maximum of accuracy is required, means must be employed to ascertain the internal characters. The method now employed with great success is that of the preparation of thin sections. Before describing this method, however, I wish to call attention to a method suggested by Mr. Bassler, which I also had made some use of prior to his publication. The method in question consists of slightly etching with acid (HCl, preferably) a smoothed portion of the surface of the specimen, and moistening with water, when the structural details can be quite distinctly seen with a good hand lens. This method is very simple and expeditious, and will suffice for the identification of almost any of the commoner and better known forms, or for use in preliminary sorting, prior to selecting the specimens for more careful investigation.

For the more careful and complete study of the internal characters nothing can take the place of thin sections.

These may be prepared in the following very simple manner. Procure a piece of sandstone such as is used for the finer grades of grindstones and whetstones; or, better still, purchase a few pounds of emery, or carborundum (the latter is the best material, and can be obtained at small expense from the Carborundum Co. of Niagara Falls) of a medium grade of fineness. In addition to the coarser sandstone or carborundum a very fine-grained razor hone, or the finest floated carborundum (No. FFF) should be obtained. For grinding with the carborundum it will be necessary to have several pieces of plate glass, or smoothed pieces (plates) of iron or copper. The other supplies needed are an alcohol lamp, or a Bunsen gas burner, if gas is available, and a mounting stage, which may be made by supporting a thin, flat metal plate on a couple of uprights at a sufficient height so that the lamp or Bunsen burner may be placed beneath it. A pair of blacksmith's nippers, and a fairly thick grade of microscope slides, cover glasses (7/8 in. square, for most purposes) and Canada balsam, which can be obtained in collapsible tubes from Bausch & Lomb, or Queen & Co., complete the list of apparatus.

Before starting to make the section the specimen should be carefully inspected to ascertain the proper place to nip off the small fragment for grinding. In general at least two kinds of sections will be needed of each specimen—one parallel with the surface (tangential) and another cutting the zooecia lengthwise (longitudinal). The pieces should, therefore, be nipped off in such positions that these two kinds of sections can be obtained by proper grinding. The fragments should now be ground on the sandstones or carborundum plates, keeping the plates well supplied with water, until a smooth, well-polished surface, cutting the zooecia in the required direction, is obtained. The specimen is next dried and cemented to a glass slide in the following manner: place a drop or two of the balsam on the slide and lay the slide on the mounting stage, which should not be too hot. Let the balsam simmer until the volatile matter is evaporated so that when the balsam is cold it will be hard and firm, but not too brittle. The proper degree of evaporation can be easily ascertained by picking up a tiny drop of the hot balsam on the point of a needle and cooling it, and then pressing the drop down upon some hard surface (of stone or metal). When the hardened drop snaps quickly off the needle, the balsam is ready to receive the polished fragment of the fossil. If the balsam is still tough or sticky, the evaporation should be carried farther. The specimen may be placed in the balsam on the slide, smoothed side against the glass, before the evaporation is complete, and the evaporation continued. Great care should be taken to make sure that no bubbles remain between the specimen and the glass. The tendency to the formation of bubbles may generally be avoided if the stage is kept at a moderate temperature. When the balsam has reached the required consistency, the slide with the fragment adhering to it is removed and allowed to cool. It may be cooled quickly by placing it on a dry cool piece of metal or stone. When cold the balsam should be hard and firm and without any tendency to pull. The specimen is now found to be securely cemented to the glass, and the grinding can be begun. Lay the slide with the specimen downward, upon the coarse sandstone or carborundum plate, and place the thumb near one end of the slide and the first and second fingers near the other end and rub the specimen against the plate, which should be kept well supplied with water, using a moderate and steady pressure, and keeping the slide always as nearly parallel to the grinding plate as possible. Continue the grinding on the coarse plate till the specimen is reduced to the thickness of thin cardboard, and then transfer to the fine grinding plate or razor hone, and continue the grinding till the specimen is so thin that all the structural details can be readily seen with a microscope magnifying about 20 diameters.

The thin flake of rock may now be covered with a cover glass in the usual manner, or, since in the grinding, the slide has probably become more or less scratched and disfigured, the flake may be warmed until the balsam is softened, and pushed, with the needles, off onto another clean slide, and then mounted.

If the balsam is too soft, the thin flake will be pulled to pieces and ruined. On the other hand, if the balsam is too hard and brittle, the flake will probably, at some stage of the grinding, separate from the slide entirely and be broken or lost. Only experience can teach one the proper degree of evaporation of the balsam. The properly mounted slide should be immediately labeled, and numbered in a manner to indicate the horizon and locality of the specimen, and the balance of the specimen from which the piece for grinding was nipped, should receive a duplicate label and number.

A great deal of time may be saved by using a diamond saw both for cutting the piece to be sectioned from the original specimen, and for trimming the greater portion of the fragment from the slide after it is cemented down preparatory to grinding. By doing this, much time may be saved in the grinding. A perfectly satisfactory foot-power diamond saw may be arranged by obtaining a foot-power emery wheel and putting the saw on the chuck in place of the emery wheel. The necessary accessories for keeping a supply of water on the edge of the wheel and preventing the water from flying in the face can be supplied by any one with a little ingenuity and at a trifling expense. The apparatus which I have used to cut many hundreds of sections cost about twelve dollars, exclusive of the diamond saw. The latter can be obtained from a number of dealers, and will cost in proportion to the diameter of the saw. At present the price is about eight dollars for a six-inch saw.

DIAGNOSES OF GENERA.

AMPLEXOPORA Ulrich.

Zoarium ramose, subramose or massive, in the ramose forms arising from an expanded base. Surface smooth or monticulose. Zooecia prismatic, polygonal, thin walled in the axial region and more or less thickened as they pass into the peripheral region, the flexure at the transition from the immature to the mature region usually abrupt. Boundary line between adjacent zooecia as seen in sections usually very distinct. Acanthopores always present and sometimes strongly indenting the walls; never of great size. Diaphragms complete, usually horizontal, but sometimes inclined, or simulating cystiphragms.

ARTHROCLEMA Billings.

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

ARTHROPORA Ulrich.

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

ARTHROSTYLUS Ulrich.

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

ASPIDOPORA Ulrich.

Zoarium consisting of one, or two or more superimposed, thin expansions, each 1 mm. or less thick, rarely parasitic, generally free, with an epithecal covering on the concave lower side; typically composed, according to age, of from one to many subequal parts, each gently convex, with the zooecia increasing in size from their margins to near their centers. Acanthopores usually present, always small. Diaphragms horizontal and closely set in the mesopores, usually wanting in the zooecial tubes, but one or more cystiphragms occur in most of the latter. (Ulrich.)

ATACTOPORELLA Ulrich.

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

BATOSTOMA Ulrich.

Zoaria irregularly ramose, with a large basal expansion. Zooecial walls thin, and irregularly flexuous in the axial region, more or less thickened in the peripheral. In the most typical species the walls are irregularly ovate, thick and ring-like in tangential sections, with neighboring zooecia in contact only at limited points, the mesopores numerous, closed at the surface, and irregular in shape and size, and the acanthopores abundant and with a larger central cavity than usual. Species vary from these to forms having polygonal, thin-walled zooecia and very few mesopores and acanthopores. Diaphragms strong, horizontal, complete, few or wanting in the axial, more abundant in the peripheral region. In the axial region of transverse sections the tubes are divisible into two sets, one larger than the other. (Ulrich.)

BERNICEA Lamouroux.

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

BYTHOPORA Miller and Dyer.

Zoaria consisting of usually very slender branches, though in one species they may attain a diameter of a centimeter or more. Surface smooth, or, in one species, with small spine-like nodes. Mesopores usually few or almost lacking, rarely abundant. Apertures of zooecia usually oblique, elongate in the direction of the branch, narrowing, in the typical species, above. In *B. meeki* they may be circular or even subpolygonal. Acanthopores well developed, sometimes numerous; rarely wanting. Diaphragms almost wanting in the zooecia, sometimes fairly numerous in the mesopores. Wall structure granular in *B. meeki.*

CALLOPORA Hall.

Zoarium usually ramose, rarely subfrondescent, or pyriform; surface smooth or tuberculated. Zooecial tubes with thin walls, varying according to the number of mesopores from circular or oval to polygonal in cross-section. Apertures closed in the perfect state by centrally perforated and often radially marked or ornamented plates, which are left behind as growth proceeds to form floors (diaphragms) of succeeding layers. Mesopores angular or rounded, more or less numerous, sometimes surrounding the zooecia; closely tabulate. Zooecial tubes attaining their full development slowly, with closely arranged diaphragms in the attenuate proximal ends, and fewer or no diaphragms in the middle part of their length. In the peripheral region these structures commonly increase again in number. Transverse sections show that in the axial region the tubes are of two sizes, the larger ones with six, seven, and most commonly eight sides, the smaller set four or five-sided. (Ulrich.)

Zooecial walls amalgamated; acanthopores entirely lacking.

CALLOPORELLA Ulrich.

Zoaria free or encrusting, thin expansions. Surface smooth or undulated. Zooecial tubes cylindrical, with thick walls, separated by one or two rows of angular mesopores. Zooecial apertures subcircular, arranged in regular intersecting series. Diaphragms numerous, straight. Acanthopores small, few.

CERAMOPORELLA Ulrich.

Zoaria incrusting, often becoming massive by superposition of numerous thin layers. Zooecial tubes short, their walls thin. Apertures more or less oblique, hooded, commonly of oval shape. The hoods are directed away from the centers of small maculae marking the surface at rythmical intervals. Mesopores abundant, often completely isolating the zooecia, their apertures usually open, sometimes closed by a thin membrane. Diaphragms only rarely present. (Ulrich.)

CHILOPORELLA Ulrich.

Zoaria rising up in flabellate fronds or compressed branches, from a greatly expanded heavy crust. Zooecial 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. (Ulrich.)

COELOCLEMA Ulrich.

Zoaria ramose, branches hollow, lined internally with a striated epitheca. Surface with or without maculae. Zooecial tubes short, with rather thick walls; apertures suboval. Peristome complete, but highest at the posterior side, making the aperture appear more oblique than it really is. Lunarium scarcely distinguishable in tangential sections. Mesopores fairly numerous, rather equally distributed among the zooecia. Diaphragms usually absent; occasionally one may be observed closing the apertures. (Ulrich.)

CONSTELLARIA Dana.

Zoaria growing from a slightly expanded base, into erect fronds, or more or less flattened, sometimes anastomosing, branches. Cells of two kinds, true zooecia with subcircular apertures, surrounded by a slight peristome; and angular thin-walled interstitial cells. At subregular intervals the surface exhibits apparently solid stellate maculae, that may be more or less elevated above the general plane of the surface, or depressed below it. Between the slender and often bifurcating rays of the macula an equal number of small groups of true cells occur, which may be placed on a plane with the surrounding surface, or, as is more commonly the case, be more or less prominently elevated into a radially divided monticule. The true cells are best developed in the inter-monticular spaces, where they are more or less isolated by interstitial cells, the mouths of which are, however, closed at the surface; in consequence, the interstitial spaces and maculae appear to be solid. In sections, the axial region is seen to be occupied only by the true zooecial tubes; here they are polygonal, with very thin walls, and few or no diaphragms. As they approach the surface their walls are slightly thickened, and a large number of thin-walled interstitial tubes are abruptly developed. These sometimes have flexuous walls, and are divided by a large number of horizontal diaphragms, which, especially just beneath the surface of fully matured examples, are closely crowded, and placed upon the same level in contiguous tubes. Small spiniform tubuli are numerous, but only in fully matured zoaria. (Ulrich.)

DEKAYIA Milne-Edwards and Haime.

Emended by Cumings.

Zoarium ramose, or variously compressed, or lobed, or frondescent; growing upward from a more or less broadly expanded basal attachment. Surface smooth or variously ornamented with monticules, maculae or spines. The cells in the monticules and maculae may be either larger or smaller than the average. Zooecia polygonal, subpolygonal or rounded. Mesopores few to numerous, angular. Acanthopores always present, typically of two sizes, the smaller present only in the mature region. Interzooecial walls always thin in the axial region, and sometimes in the mature region; at times considerably thickened in the mature region, always consisting (in sections of the mature region) of three elements: a median zone (usually light colored), in which are lodged the mesopores and acanthopores; a definite dark band on either side, bounding the median zone and encircling the zooecia; and a band (usually light colored) of sclerenchyma immediately encircling the zooecial cavity. Diaphragms few or almost lacking, to numerous; nearly always straight and horizontal. Only in exceptional cases are a few cystoid diaphragms present. When mesopores are present the diaphragms are more numerous in the mesopores. (Cumings.)

I see no reason to modify my contention that the genera *Heterotrypa* and *Dekayella* should be combined with the genus *Dekayia* to form a single genus. This is not the place to go at length into the discussion of this point; but since Mr. Ulrich has recently in a revision of the Trepostomata adhered to his original grouping of the species here referred to the genus *Dekayia,* a word of explanation is demanded for rejecting his views. Ulrich and Bassler say "as to the value of the three genera discussed by Mr. Cumings, we do not deem this the proper place to go into the subject in detail. However, we still consider the three genera distinct and very convenient in classification if not wholly natural groups. It is true that Ulrich some years ago expressed the idea of combining the three genera, but this was at a time when *Dekayella* was the only genus of the three of which species were known in the Mohawkian and Utica, and when it seemed quite probable that the Lorraine species of *Dekayia* and *Heterotrypa* were derived from the earlier genus. Now typical species of both *Dekayella* and *Heterotrypa* are known to range side by side through the Mohawkian and Cincinnatian groups." And again, "Cumings has shown that acanthopores of all sizes, grading from that of the small set to the large kind are present in the same section of various species of *Dekayia, Heterotrypa*, and *Dekayella.* We admit that this is so if the section passes through all the stages of growth from the very mature part of the zoarium to the less mature regions."

We pass by the matter of convenience of the three groups into which Ulrich has divided these species, since the only satisfactory basis for a genus is the *natural group.* The question seems to be as to whether two sets of acanthopores are present in all three groups or are confined to the single group of *Dekayella.* Ulrich and Bassler contend that the latter is the case if the fully mature portion of the zoarium alone is considered. Any one is at liberty to examine figures 7, 10, 12 and 14, on plate ix of my paper on the revision of these genera, and conclude whether they cut the mature or the immature region of the zoarium. These sections, as any one knows who is familiar with the appearance of tangential sections of the Trepostomata, cut the fully matured portion of the zoarium; and they just as surely contain the two sets of acanthopores. Figure 9 cuts just at the passage from the immature to the mature portion of the zoarium, and also shows the two sets of acanthopores. In the type species of the genus *Dekayia—D.*

aspera, two sets of acanthopores are shown *in the fully matured region* of the zoarium, as shown in figure 10, plate ix, of my paper, and again in figure 10, plate x. There is besides these facts the important fact that the species *Dekayia subfrondosa* Cumings, shows these two sets of acanthopores beyond any question, and in the basal portion of the zoarium has the polygonal zooecia and few mesopores of *Dekayia* (s. s.) and in the terminal branches has the rounded zooecia and the numerous mesopores of *Dekayella* Ulrich. While it has the tabulation of the zooecia in *Heterotrypa,* and it is also a definitely frondescent species as in *Heterotrypa.* Taken together these three genera form one single compact group, with a fair representation throughout the Mohawkian and Cincinnatian series. This group presents within itself no more variation than the genus *Homotrypa* which has the same or greater range and is more prolific of species.

DICRANOPORA Ulrich.

Zoarium large when complete, composed of numerous small ligulate joints. The segments are flattened, from one-fourth of an inch to one inch in length, with the edges subparallel to near the upper end where they suddenly diverge, and are dichotomously divided into two short branches, the ends of which are thickened and solid, and articulate with the next succeeding segments. Cell-mouths ovate to subquadrate, and arranged between raised longitudinal lines. Usually the cells in from one to three rows along the margins have an oblique direction. No interstitial cells. (Ulrich.)

ERIDOTRYPA Ulrich.

Zoaria ramose, branches slender. Zooecia more or less oblique with thick walls, the tubes intersected by diaphragms only. The latter may be wanting in the axial region, are in most cases absent for a short distance within the apertural edge, but always present and close together in the turn from the axial into the narrow peripheral region. Mesopores with close-set diaphragms, varying in number, sometimes abundant, at other times very few. Acanthopores small, never numerous, sometimes wanting. (Ulrich.)

ESCHAROPORA Hall.

"Coral consisting of a solid cylindrical or subcylindrical stem, gradually tapering above, expanded and attached by root-like ramifications below; surface entirely celluliferous; mouths of cellules oval, scarcely contracted, enclosed in a rhomboidal space formed by elevated oblique lines which cross the coral in two directions; cellules consisting of oval tubes of nearly equal dimensions throughout, which radiate in an ascending direction from an imaginary axis." (Hall, original diagnosis.)

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

FENESTELLA Lonsdale.

"Professor Phillips having informed me that the late Mr. Miller of Bristol employed the word *Fenestella* to distinguish a mountain limestone coral possessing generic characters similar to those of the fossils represented Pl. 15, f. 15 to 19, I have conceived it my duty to adopt the name, though not published; and I have ventured to call one of the species *Fenestella Milleri,* as a tribute of respect to departed talent.

Gen. Char.—A stony coral, fixed at the base and composed of branches which unite by growth and form a cup. Externally the branches anastomose, or regularly bifurcate; internally they form a network, the intervals being generally oval. One row of pores on each side of the branches externally, the openings being circular and projecting when perfect. The branches, when regularly bifurcated, are connected by distant, transverse processes, in which no projecting pores are visible. In well-preserved specimens of the base of apparently old corals, the pores or foramina on one side of the branch have united by growth to those on the side of the adjoining branch, and constitute solid bars, either stretching transversely and simply across the intervals, or uniting obliquely three and sometimes more together."—Lonsdale, Murchison's Silurian System, p. 677. 1839.

The above is the original diagnosis of this genus by Lonsdale. In the Geology of Russia and the Ural Mountains, Lonsdale so modified his diagnosis of the genus as to include a very much wider range of forms, having the zooecia on either the inside or outside of the zoarium. Within recent years the genus has been very narrowly restricted (see Ulrich in Zittel-Eastman Textbook of Paleontology) to forms like *Fenestella plebeia,* with the zooecia on the inside of the zoarium. That this is not in keeping with the original diagnosis of the genus can be seen by anyone who will read it as quoted above. In my studies on the development of *Fenestella* I have shown that whether or not the zooecia are on the inside or outside of the zoarium is a matter of very considerable importance in the *Fenestellidae*; and hence that it follows that the restriction originally placed on the genus by Lonsdale, limiting it to forms with the zooecia on the *outside* of the zoarium, is important and should still enter into any diagnosis of *Fenestella.* That the genus as at present constituted is still an unnatural group is certain; and much redistribution of the species into other and probably several new genera will be required when the ontogeny of the various forms is finally worked out. Such work is necessarily slow and favorable material exceedingly scarce, nevertheless it is, I believe, the only way to place this group of fossils in a satisfactory condition taxinomically. In the meantime it is probably not wise to disturb the present arrangement of the species, however unsatisfactory it may be. The only species known from the Cincinnati group has, if I am not mistaken, the zooecia on the outside of the zoarium, as have the majority of the keeled species of the older rocks. Nothing is as yet known concerning its ontogeny, although I have made considerable effort to obtain favorable material, which is so far lacking.

GRAPTODICTYA Ulrich.

Zoaria rising from a pointed articulating base into continuous dichotomously divided narrow fronds. Zooecia with subcircular apertures, 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 laminae straight in transverse sections. (Ulrich.)

HELOPORA Hall.

"Simple or branching cylindrical stems, often swelling at the upper extremity, poriferous on all sides; pores oval or subangular, arranged between longitudinal elevated lines." (Hall, original diagnosis.)

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

Ulrich believes that further study of the two sections of this genus as here constituted will result in their separation into distinct genera.

HOMOTRYPA Ulrich.

"Zoarium ramose to subfrondescent; surface smooth, or with more or less prominent monticules. Cells circular, ovate or polygonal, with moderately thin walls. At intervals there are groups of larger-sized cells, which again sometimes inclose small stellate maculae, consisting of much smaller, angular cells. The surface extensions of spiniform tubuli may often be observed at the angles of the cells. In the axial portion of the branches or fronds, the tubes are immature, and may be crossed by straight diaphragms; usually diaphragms are entirely wanting in this region. The tube-walls are excessively thin until they reach the peripheral regions, when they are much thickened, and bend outward to open at the surface. In the peripheral or mature portion of the zoarium, the tubes are provided with a series of cystoid diaphragms; the space intervening between their flexuous inner line, and the opposite wall of a tube, is crossed by equally numerous straight diaphragms. The tube-walls are perforated by rather large connecting foramina. In the tuberculated species the spiniform tubuli are numerous, but very small, and not easily recognized, while in the smooth forms they are much larger, and constitute a conspicuous feature in sections. The internal structure of the small tubes, which form the maculae of some species, is not remarkably different from that of the ordinary tubes. The only difference that I have been able to detect is found in the fact that cystoid diaphragms are but rarely developed in them." (Ulrich, original diagnosis.)

According to Bassler, the species of *Homotrypa* may be classed into two well-defined groups. In the typical section (*Homotrypa curvata* group), diaphragms as well as cystiphragms, are present in the peripheral region. The second (*Homotrypa communis* group) seldom, if ever, has the diaphragms developed either in the axial or the peripheral region of the zooecial tubes. This group is the more common in the Richmond formation. Ulrich's statement, therefore, in regard to the presence of diaphragms in the mature region will hold only for the *curvata* group—the only one known at the time his diagnosis of the genus was drawn up.

The acanthopores, which are practically lacking in some of the species recently described, do not present the peculiarity with regard to the tuberculated and smooth species that Ulrich mentions in his original description, although that, again, was true of the species known at the time his diagnosis was written. In the *communis* group they commonly present an indistinct or fuzzy appearance in tangential sections. Several of the recently described species show the communication pores very beautifully. In fact, they are a very common sight in thin tangential sections of the thick-walled species generally. I believe there can no longer be any doubt of the verity of these structures.

This is one of the most important and abundantly represented genera of the Trepostomata. It is well represented in the Mohawkian series and again abundantly represented in the Richmond formation, with a meagre representation in the Utica, and a fair representation in the Lorraine. The *communis* group is confined to the Richmond formation, as now defined.

LEPTOTRYPA Ulrich.

The genus *Leptotrypa* has recently been restricted by Ulrich and Bassler to a fraction of the species formerly referred to it. This is eminently proper since the genus as until recently constituted formed an incongruous group. The type species is found to belong to the Amalagamta and is placed in the *Heterotrypidae* (sic.). As restricted, the genus includes several parasitic forms (*L. minima, L. ornata* and *L. clavicoidea,* and several undescribed species). Ulrich and Bassler give the following very brief diagnosis of the genus as restricted:

Zoarium forming thin, evenly spread, parasitic expansions; acanthopores very small, never abundant; no mesopores.

MONOTRYPELLA Ulrich.

This genus has recently been restricted by Ulrich and Bassler to the genotype and such other ramose *Amplexoporidae* as differ from *Amplexopora* only in the absence of acanthopores. The genotype (*M. aequalis*), or rather the specimen from which the original set of figured sections were cut, is certainly without acanthopores, but, Ulrich and Bassler state, no other of the specimens that have heretofore been referred to that species is without them. These authors are inclined to treat the original specimen of *M. aequalis* as unique, although they admit the bare possibility that it may be an abnormality. It would seem to me better, since all the other species except the genotype and *M. pulchella* have now been removed from the genus, to entertain the view that the genotype is abnormal and remove it to the genus *Amplexopora,* thus doing away entirely with the genus *Monotrypella,* which seems to rest on such an insecure foundation. The species *M. quadrata* and its near relatives are removed by Ulrich and Bassler to the new genus *Rhombotrypa.*

MONTICULIPORA d'Orbigny.

"Cellules serrees, poriformes a la surface, d'un ensemble rameux ou encroutant couvert de petites sailles coniques."—d'Orbigny, Prodrome de Paleontologie, p. 25, 1850.

The above diagnosis is quoted merely as a matter of historical interest. The forms placed in the genus *Monticulipora* by d'Orbigny, under the original diagnosis, would constitute a very considerable section of the Order Trepostomata as now understood. By successive restrictions the genus has come to consist of only a few very closely related and characteristic species. For this restriction we are indebted to our foremost student of the fossil Bryozoa, Mr. E. O. Ulrich. The following is Ulrich's diagnosis of the genus:

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

Recently a few forms heretofore referred to the genus, as restricted, have been removed to the new genus *Orbignyella* by Ulrich and Bassler. The forms so removed lack the granulose wall structure of *M. mammulata* and have less clearly defined cystiphragms. As now constituted the wall structure is the most important character of the genus *Monticulipora.*

NICHOLSONELLA Ulrich.

Zoaria consisting of irregularly intertwining flattened branches or fronds, sometimes laminated. Zooecia 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 zooecia. Walls of both the zooecia and mesopores thin, and in the mature region traversed longitudinally by minute tubuli. The interzooecial spaces are filled by a calcareous deposit, into which the minute tubuli continue, but in which the mesopore walls become unrecognizable. Mesopores with rather thick and numerous diaphragms. (Ulrich.)

PACHYDICTYA Ulrich.

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

PERONOPORA Nicholson.

Zoarium laminar or encrusting. Two distinct sets of tubes are present, distinguished by their size and structure. The large tubes (zooecia) are furnished with incomplete tabulae (cystiphragms) of the type of those found in the corresponding tubes of *Prasopora*. The mesopores are numerous, interspersed among the zooecia, sometimes partially aggregated into clusters; their tabulae always more numerous, close set, horizontal, and complete. Acanthopores are usually largely developed, though occasionally apparently wanting. The walls of the zooecia are thickened and seemingly fused together in adjoining tubes, their primitively duplex character being entirely lost. (Nicholson.)

The above diagnosis is slightly modified from the original diagnosis of Nicholson, the changes being merely in the substitution of the modern terminology for his.

Nicholson's *Peronopora frondosa* is our *P. pavonia*; his *P. molesta* is our *Monticulipora molesta* and his *P. cincinnatiensis* is our *Monticulipora cincinnatiensis,* while his *P. ortoni* is our *Atactoporella ortoni.* It will be seen therefore that the present conception of the genus is quite different from that of Nicholson. The genus was restricted to its present significance by Ulrich in 1882. As now understood the genus is restricted to bilaminar forms such as *P. decipiens* Rominger (=*P. pavonia* d'Orb.); and the addition of this restriction is almost the only change that need be made in the above diagnosis of Nicholson. The zoaria are, however, never genuinely incrusting, though they do frequently arise from a broadly expanded base. The surface is sometimes smooth, and sometimes has low-rounded monticules. Maculae of smaller cells than the average are quite commonly present and sometimes form a conspicuous feature. The zooecia spring from either side of a double median plate or lamina, are at first prone, but rapidly turn outward and emerge at right angles to the surface. Apertures circular or subpolygonal. The other characters as in the diagnosis of Nicholson, given above.

PETIGOPORA Ulrich.

Zoaria consisting of small, more or less circular patches, on the surface of other bryozoa, or of brachiopods, etc. Always thin, with short, direct zooecia, no mesopores, and rather large acanthopores. The acanthopores sometimes give rise to spines at the surface. Diaphragms few or lacking. Walls rather thick at the surface.

It is quite possible that some of the species referred to this genus are the young of species of *Dekayia*. In some cases, however, they have a different range from any species with which they might reasonably be thus associated; and in such cases it is hard to believe that they can be young stages. Some of the species are quite common and widely ranging forms.

PRASOPORA Nicholson and Etheridge Jun.

Zoarium consisting of concavo-convex, hemispherical, subglobular, conical, pyriform or more or less irregular masses with a wrinkled epitheca on the basal surface. Upper surface either smooth or with more or less prominent monticules. Zooecia polygonal or rounded, thin-walled, usually more or less completely isolated from each other by small angular mesopores; direct. Acanthopores nearly always present, but scarcely ever abundant or large. Diaphragms numerous and close-set in the mesopores; less abundant and more widely spaced in the zooecia, where they are always accompanied by a well-developed, usually overlapping series of large cystiphragms. In some species the cystiphragms are isolated and present semicircular, semielliptical or pyriform outlines, at times one being superposed upon another. They may occur on one or both sides of the zooecial wall. The diaphragms nearly always spring from the backs of the cystiphragms.

This genus is most abundantly represented in the Trenton rocks, is absent in the Utica and Lorraine and is represented by a single abundant species in the Richmond of Ohio, Indiana and Illinois.

PROBOSCINA Audouin.

Zoaria adnate, creeping over the surface of brachiopods, corals, other bryozoa, etc. Zooecia subtubular, more or less immersed in the coenenchyma, with circular erect apertures. Arranged in two or more continguous series. This feature constitutes the chief difference between this genus and *Stomatopora*. Budding lateral or terminal, or both.

This genus, although having a very small specific representation, is present in most of the divisions of the Ordovician rocks from the Black River formation to the top of the Richmond, and usually in considerable abundance of individuals.

Under the diagnosis of the genus *Stomatopora* will be found a discussion of the status of that genus and the present one.

PTILODICTYA Lonsdale.

"Thin, elongated expansions, having on each surface small quadrangular cells not convex, which penetrate the coral obliquely, and are arranged with respect to the surface, along the middle of the specimen, parallel to the elongated direction of the coral, but on the sides obliquely from it. Surface, a very thin calcareous crust traversed by slightly raised ridges, marking the boundaries of the cells; towards the margin the crust thickens, the indications of the cells are less distinct, and at the edge are invisible; but cells are traceable close to the margin where the crust has been removed; opening of the cells small, transversely oval ? no indication of a central partition parallel to the surface." (Lonsdale, Murchison's Silurian System, p. 676, 1839.)

This genus, which has been the receptacle at various times of a large and varied assortment of more or less unrelated forms, was restricted to its present bounds by Ulrich in 1893, in the Geology of Minnesota, p. 165. I have ventured to quote the original diagosis of Lonsdale as a matter of historical interest, in view of the increasing difficulty of obtaining access to Murchison's great work. Ulrich's diagnosis is as follows:

Zoaria bifoliate, simple, unbranched, lanceolate or falciform. terminating below in a solid, striated, pointed base, which originally fitted loosely in the centrally situated cup-shaped depression or socket of a small basal expansion. The latter grew fast to foreign bodies, is radially striated, and has small cell openings in the furrows between the striae. In very young examples, and in certain small species in which this condition seems to be permanent, the entire zoarium consists of longitudinally arranged, narrow, oblong-quadrate zooecia. As growth proceeds new zooecia, both wider and differently arranged, were added on each side. These lateral zooecia may be arranged in oblique or transverse rows, so as to produce the "pinnate" or "plumose" arrangement prevailing in the typical species, or they may form diagonally intersecting rows, with groups of large cells or subsolid spots raised at regular intervals into monticules. Zooecial apertures subquadrate. rhomboidal, or rounded, the shape depending largely on their arrangement. Both hemisepta usually well developed. Primitive cell, with thin walls, subelongate, hexagonal, or lozenge-shaped, in contact at all sides. In the vestibular or outer region, the walls are more or less thickened, solid, and with a double row of exceedingly minute dots; the latter rarely preserved and seen only in tangential sections. No median tubuli. (Ulrich.)

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. Zooecial apertures subcircular or elliptical, arranged alternately in longitudinal series between slightly elevated, straight or flexuous ridges, carrying a crowded row of small, blunt spines. Space immediately surrounding apertures sloping up to summits of ridges." (Ulrich.)

RHOMBOTRYPA Ulrich and Bassler.

"Ramose *Amplexoporidae* with zooecial tubes in the axial region regularly quadrate or rhombic in cross-section. Acanthopores usually wanting, always shallow, rarely distinguishable internally. True mesopores absent, but wall-less tabulated interzooecial spaces occur in several of the species." (Ulrich and Bassler.)

This genus has recently been erected by Ulrich and Bassler for the reception of the species of which the well-known *Monotrypella quadrata* (Rominger) is the type. The chief and almost the only difference between *Monotrypella* and the new genus is in the quadrate of rhombic cross-section of the zoöecia in the immature region of the latter. Since this peculiarity seems to be very constant, however, there seems to be ample warrant for the establishment of the genus.

The quadrate zooecia are usually best seen in cross-sections of the branch; but they are also frequently beautifully shown at the ends of branches, and sometimes, especially in small individuals, they form a conspicuous feature of the greater portion of the entire surface of the branch, and give it a characteristic and unmistakable appearance. The genus is not known to occur in rocks older than the Richmond formation, but it is quite characteristic of the latter. It is represented by one species in the Lockport shales of the Niagara series.

RHOPALONARIA Ulrich.

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

The only evidence usually seen of the presence of this genus is the peculiar pits excavated by the stolons in the surface to which the organism was attached. These tell us nothing about the zooecia except their arrangement. The oldest known species is *R. venosa* from the Richmond formation.

SPATIOPORA Ulrich.

"Zoaria forming thin parasitic crusts upon foreign bodies, the shells of *Orthoceras* being the most favored. Surface even or with monticules. Zooecia short, with direct and more or less irregularly shaped apertures. Lunarium scarcely perceptible even in thin sections. Mesopores very few, usually absent, when present occurring chiefly as 'maculae.' Interspaces often with large blunt spines (? acanthopores). Walls of zooecia moderately thin, with the characteristic structure pertaining to the family." (Ulrich.)

STICTOPORELLA Ulrich.

"Zoaria bifoliate, growing from a broad basal expansion into narrow, parallel-margined, branching stipes, simple leaf-like fronds, or cribrose expansions. Zooecia with the primitive portion tubular, unusually long, generally without hemisepta, the inferior one only occasionally being present. Apertures elliptical, placed at the bottom of a sloping area, the latter usually polygonal. More or less numerous, thick-walled, untabulated mesopores occur between the zooecial apertures and line the zoarial margins. Maculae, composed of clustered mesopores, and sometimes of zooecial apertures of larger size than the average, commonly scattered over the surface of the frondescent species. Tangential sections of favorably preserved specimens show that both the zooecia and the mesopores are separated from each other by a sharply defined line of minute pore-like dots. True median tubuli and diaphragms wanting." (Ulrich.)

STIGMATELLA Ulrich and Bassler.

"Zoarium variable, ranging from incrusting to irregularly massive or ramose. Zooecia angular, rounded, or irregularly petaloid, the shape depending upon the presence (or absence) of mesopores and the number of acanthopores. Typically the zoarial surface exhibits at regular intervals maculae or spots composed of mesopores, although in some species the usual monticules or clusters of large cells occur. Acanthopores always present but variable in number, intermittent, developed chiefly in narrow zones, sometimes inconspicuous but more often so numerous as to give the surface a decidedly hirsute appearance. Mesopores, when present, developed in mature region only, their number variable even for the same species. The zooecial tubes have thin walls in the axial region and these become but slightly thickened in the peripheral region, where a few unusually delicate diaphragms are inserted. In vertical sections the walls exhibit at rather regular intervals in the peripheral region thickenings somewhat similar to those occurring in *Stenopora.* These thickenings occur approximately at the same height in the walls, and tangential sections through these zones give the full development of acanthopores. Minute structure of walls as shown in tangential sections, of the type that characterizes the *Heterotrypidae.*" (Ulrich and Bassler.)

Ulrich and Bassler have recently erected this genus to receive several forms that have heretofore been referred to the genera *Monticulipora, Monotrypa* and *Leptotrypa* of Authors, and for a number of recently described species. The distinguishing character is the periodic thickening of the walls, and the intermittent development of the acanthopores. Of described species this genus includes *Leptotrypa clavis, L. irregularis* and *Monticulipora dychei.*

STOMATOPORA Bronn.

Zoaria adnate, forming delicate dichotomously branching chains of zooecia, creeping over the surface of foreign bodies. These branches frequently inosculate in such a way as to give to the whole expansion a reticulate or web-like appearance. The individual zooecia are tubular, pear-shaped, oval, club-shaped, sometimes almost hemispherical; arranged in one or more series; more or less immersed in the coenenchyma. Apertures round, salient, sometimes notably drawn out; usually situated at the distal end of the zooecium, but sometimes near the middle of its upper surface. Walls finely porous.

This diagnosis will, I believe, admit both the Ordovician and Mesozoic forms commonly referred to this genus. There is no question, however, that this is an unnatural group as it stands. I cannot take the space at the present time to discuss the various points which arise in a critical consideration of the great array of species which it is the habit of students of the Bryozoa to refer to this genus and to the genus *Proboscina.* I wish only to call attention to the work of Mr. W. D. Lang of the British Museum, which is along precisely the lines that may be expected to yield the most valuable results, and which has already been the means of showing us the artificiality of the group as at present constituted. Mr. Lang's studies are still in progress, and I sincerely hope that he will at some time take into consideration the older Paleozoic as well as the Mesozoic species. It seems to me certain that these species, so widely separated, in time will be found to fall into distinct genera. As Lang has already pointed out, the genera *Stomatopora* and *Proboscina* are polyphiletic in origin, "and in some cases a given species of *Proboscina* may be at the head of a series of forms, the simplest of which are undoubtedly *Stomatopora.*" In like manner I believe it will be found that *Stomatopora* as at present constituted will afford material for a number of genera standing as radicals of lines leading into various genera of Cylostomata besides the genus *Proboscina.* These genera will be found to converge in the older rocks into a few (and possibly one) very simple types. The ordovician type of *Stomatopora* comes surprisingly near fulfilling the conditions not only of a primitive Cyclostome, but of a primitive Bryozoan. The time is not yet ripe to go into this fertile subject further than to make suggestions, and this I have done in my paper on the Development of Paleozoic Bryozoa, to as great an extent as the facts at hand permit. The method of Lang is in entire agreement with my own, namely, to study first the ontogeny (or rather the astogeny) of the individuals of a species and then to construct the genera strictly on the basis of phyletic relationships thus pointed out. This is the method of Hyatt and Beecher and Jackson, that has already proved so valuable in the rearrangement of the genera of the Brachiopoda, Cephalopoda, and Trilobita.

DESCRIPTION OF SPECIES.

AMPLEXOPORA CINGULATA Ulrich.

Plate VI, figs. 1, 1a; Plate XXVI, fig. 3.

Amplexopora cingulata Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 254, pl. xi, figs. 5-5c.

"Zoarium ramose, consisting of cylindrical or subcylindrical branches, which divide dichotomously at irregular intervals, and vary in diameter from three to seven-tenths of an inch. The surface is perfectly smooth, and destitute of monticules. When in the best state of preservation, the cell-apertures are subpolygonal, the walls are moderately thin, and occupied by small granules. In the usual condition the cell-apertures are rounded, the walls comparatively thick and smooth. The surface also shows groups of from seven to fifteen cells, of a larger size than the average, their diameter varying from 1/80th to 1/60th of an inch, while that of the smaller ordinary cells is almost constantly about 1/90th of an inch.

"Tangential sections show that the cells are of one kind (*i. e.,* no interstitial tubes are present), and that, between the groups of larger cells, they are of a very uniform size. The original polygonal walls can still be readily recognized; but their internal cavities are more or less rounded by a secondary deposit of dark, concentrically laminated sclerenchyma, which has a variable thickness in the different sections. The original line of demarkation between adjoining tubes is always more or less distinctly preserved, and is made especially conspicuous by the numerous small spiniform tubuli, which, in this species, are developed only on the line of junction. One is situated at each angle, and one or two more on the line between the angles.

"Longitudinal sections show that the tubes in the axial region have very thin walls, and are traversed by remote horizontal diaphragms, from two to three times the diameter of a tube distant from each other. As they approach the surface, they bend outward rather abruptly, their walls are much thickened, and the diaphragms become much more numerous. The tube-wall in the peripheral region is divided into four longitudinal portions, by three distinct dark lines. The two inner portions represent the original walls of two adjoining tubes, and are composed of a fibrous structure, the fibers being directed obliquely upward to meet along the dark central line. The two outer zones, which are of a darker color than the inner layers, represent the secondary deposits within the original polygonal walls of the tubes. The diaphragms in the outer portion of the tubes are usually nearly horizontal. All of my sections, however, show a few very peculiar diaphragms. In the section they are represented by two curved plates which spring from the opposite walls of the tube, nearly meeting, either in the center, or nearer one side of the tube-cavity, when they proceed as nearly parallel lines downward to the next straight diaphragm. Their shape was undqubtedly that of a funnel, of which the position of the lower tublar portion, with regard to the expanded mouth, was somewhat erratic.

"In transverse sections the tubes in the axial region have very thin walls, and are strictly polygonal." Ulrich, *loc. cit.*

To this species I have referred a specimen from the lower part of the Lorraine, that seems to possess all of the characters enumerated above except that I have not detected any of the infundibular diaphragms mentioned by Ulrich. The walls are also not quite as thick as represented in Ulrich's figures.

1.34C14a.

AMPLEXOPORA PETASIFORMIS (Nicholson).

Plate VI, figs. 3, 3a; Plate XXVI, fig. 2.

Monticulipora (*Monotrypa*) *petasiformis* Nicholson, 1881, Genus Monticulipora, p. 190, fig. 40.

"*Spec. Char.*—Corallum small, discoidal, from six to eighteen lines in diameter, somewhat variable in shape, but always with a flat or concave base, which may be in part attached parasitically to some foreign body, but is always covered with a concentrically striated epitheca over the rest of its extent. From this basal plate the short corallites spring nearly at right angles throughout, and they either form a thin disc, or they give rise, more commonly, to an expansion which is thin at its edges, but is prominently elevated towards its center, thus resembling in form the 'cap' of many mushrooms. In other cases, there may be two of these prominences; and, whether single or double, the superior elevation may project above the base to a considerable height as compared with its width at the base. The maximum height varies from three lines to nearly one inch. The upper surface is covered with the calices, which are thin-walled, polygonal, and approximately equal in size, varying from 1/80th inch to 1/60th inch in diameter. There are no small interstitial corallites of any kind, but the surface shows numerous clusters of tubes which are slightly larger than the average, and which are very slightly elevated above the general level. The walls of all the corallites are thin and delicate, no thickening taking place as the surface is approached. The tabulae are numerous, complete, equally developed throughout the entire length of the corallites, straight or slightly curved, and mostly from 1/100th to 1/90th inch apart.

"*Obs.*—This form from its general aspect would be set down as a near relation of *Monticulipora petropolitana,* Pand., from which, however, it is even superficially separable by its peculiar and seemingly constant form. In its minute structure the present species is quite distinct from *M. petropolitana,* Pand., and, in fact, possesses characters which sufficiently distinguish it from all the forms externally like it. Tangential sections show that there is a total absence of small interstitial tubuli, and that, except for the previously mentioned existence of clusters of corallites of a size slightly above the average, the tubes are approximately alike in size. The walls are exceedingly thin, but nevertheless, in sections sufficiently thin, show a distinctly duplex character, the boundary lines between the walls of contiguous tubes being expanded into angular nodal points at their angles of junction. Long sections show that there is no difference in internal structure between the average corallites and the clusters of slightly larger tubes which are interspersed amongst these, all being furnished with numerous complete tabulae. The two species most nearly allied in structure to the present form are *M. undulata,* Nich. (the rounded examples from the Hudson River Group), and *M. irregularis,* Ulrich. From the former of these, *M. petasiformis* is distinguished by its different external shape, by the fact that its corallites spring perpendicularly from a basal epithecal plate, instead of radiating from a basal or central point, by the absence of even a few small corallites, and by the much greater development of the tabulae, these structures not being disposed at corresponding levels in contiguous tubes. From *M. irregularis,* Ulrich, the present species is readily separated by its want of the nodulated surface and radiated corallites of the former, and by the great abundance of its tabulae."—Nicholson, *loc. cit.*

5.9A6....1.34C6.

AMPLEXOPORA PUSTULOSA Ulrich.

Plate VI, figs. 4-4b, Plate XXVI, fig. 1.

Amplexopora pustulosa Ulrich, 1890, Geol. Illinois, VIII, p. 451, pl. xxxvi, figs. 3-3e.

"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. Zooecial walls a little flexuous, thickened somewhat in the cortical region. Zooecia 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 diaphrams 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."—Ulrich, *loc. cit.*

1.34B4-5. Occurs abundantly just above the level of the gerontic *Platystrophia lynx* layer in cut No. X on Tanner's Creek.

AMPLEXOPORA ROBUSTA Ulrich.

Plate VI, figs. 5-5b.

Amplexopora robusta Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 82, pl. i, figs. 1-1b.

"Zoarium ramose, consisting of cylindrical, oftener of flattened branches, dividing dichotomously at rather frequent but irregular intervals, and usually varying in diameter from .4 inch to .7 inch. A very large specimen in my cabinet has a length of 4.3 inches; the central stem is flattened, and varies in diameter from 1.1 inches to 1.7 inches. The bases of two branches are on one side, and three on the other, the mean diameter of which is about .6 inch. Monticules are not developed. The cells are moderately thin-walled, polygonal, and consist of one kind only (*i. e.*, the interstitial cells are wanting); their arrangement is quite regular, and, when well preserved, show at the angles of junction the elevated points of the spiniform tubuli. At intervals of about .15 inch the surface exhibits conspicuous clusters of cells larger than the average, with a mean diameter of 1/60th of an inch. The smaller or ordinary cells have a diameter varying from 1/100th to 1/90th of an inch.

"Tangential sections show that the cell-walls are comparatively thin and polygonal, and that their cavities are only occasionally rounded by a secondary deposit of sclerenchyma; and further that the original line of separation between adjoining cells is always more or less distinctly marked. The spiniform tubuli do not constitute a conspicuous feature in sections of this species, and unless carefully examined might be overlooked. With an occasional exception they always occupy the angles of junction of the cells. (Their appearance is very well represented by the figures.) Lastly, in many sections some of the cell-cavities inclose a small circular ring, that is due to the peculiar funnel-shaped diaphragms seen in longitudinal sections.

"In longitudinal sections the tubes in the 'immature' region are thin-walled, and crossed by straight diaphragms from two to four tube-diameters apart. The nearly equal curve of the tubes, from the axis of the branch to the peripheral portion, constitutes a characteristic feature of the species. As they enter the peripheral or 'mature' region their walls are considerably thickened, and the diaphragms become much more numerous, being from less than one-half to one tube-diameter distant from each other. The funnel-shaped diaphragms noticed in the preceding species (*A. cingulata*) are much more numerous in this species. Not infrequently two or three open into each other in such a manner that by the coalescence of the contracted parts of the superimposed funnels, a smaller irregular tube is found within the proper tube-cavity. These diaphragms in their normal condition are represented in the section by two thin converging lines, springing from the walls of the tubes, and nearly meeting near the center of the tube cavity. Frequently, however, one of these lines is missing. In this case the diaphragm extends from one wall nearly across the tube toward the opposite wall.

"Superficially, the species above described resembles the type of the genus, though not nearly enough to be confounded with it by one experienced in the determination of this group of fossils. The cell-walls are thinner, and the groups of larger cells more conspicuous in *A. robusta* than in *A. cingulata.* Internally, the comparatively thin cell-walls and numerous funnel-shaped diaphragms, and the small number of spiniform tubuli of *A. robusta* will further distinguish it from that species. Care must be taken in separating the species from *Monotrypella aequalis,* Ulrich, which the smaller specimens of *A. robusta* strongly resemble. The former, however, is restricted to the lower 150 feet of the strata exposed at Cincinnati, O., while the latter is limited to a few feet of strata at least 225 feet higher in the series."—Ulrich, *loc. cit.*

A description of this species is inserted because, although I am not sure that I have any specimens that can certainly be referred to it, nevertheless it must quite certainly occur in Indiana.

AMPLEXOPORA SEPTOSA Ulrich.

Plate VI, figs. 6-6b; Plate XXVI, fig. 4.

Atactopora septosa Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 125, pl. xii, figs. 7-7c.

"A ramose species, growing from an expanded base, by which it is attached to foreign bodies. Branches bearing considerable resemblance to those of *Chaetetes* (*Monticulipora*) *pulchellus* or *fletcheri.* Surface exhibiting low, broad and rounded tuberosities;

which are placed at distances apart of about one line, and carry groups of larger tubes than those of the ordinary size. Tubes small polygonal, quite regularly arranged, without any minute interstitial cells; walls thin; about eight of the tubes, of average size, occupy the space of one line; about six of the tubes of larger size occupy the same space. Pseudo-septa well developed, more easily detected in slightly worn specimens than in those perfectly preserved; from one to five in each tube.

"In longitudinal sections the tubes are seen to be nearly vertical in the middle of the branch; here they have very thin walls, and are crossed by excessively thin and remote tabulae; they then bend abruptly outward, and as the surface is approached the tabulae are more closely set, and the walls become stouter; here, also, the pseudo-septa make their appearance, as is demonstrated by the darker lines which extend parallel with, and between, the true walls of the tube. The diaphragms are so thin that they can easily be overlooked.

"In tangential sections the pseudo-septa are very conspicuous and usually number three or four in each tube. Transverse sections show the tubes in the center of the branch to be polygonal, without minute intercellular tubuli, and with very thin walls.

"From an external examination, when the pseudo-septa are not visible, it is not an easy matter to distinguish specimens of this species from certain varieties of *Chaetetes* (*Monticulipora*) *pulchellus*; but when worn there is no difficulty, as the septa, when viewed through a hand lens, give a peculiar and characteristic appearance to the specimens. Of course, tangential sections will immediately demonstrate their distinctness. The ramose growth of the species will distinguish it from the other species of *Atactopora.*"—Ulrich, *loc. cit.*

This is a very characteristic and easily recognized species, owing to the presence of a very large number of acanthopores that conspicuously indent the zooecia. The "pseudo-septa" mentioned in the above description are these acanthopores. Tabulae are rather numerous in the mature region and are frequently more or less curved, sometimes appearing to run into each other, as seen in longitudinal sections. This feature, however, is not peculiar to the present species, but characterizes more or less constantly all the species of *Amplexopora.* The boundary line between adjacent zooecial walls is very well marked.

1.34C13....1.38Ba, and at other localities in the base of the Lorraine.

AMPLEXOPORA SEPTOSA var. MULTISPINOSA Cumings.

Plate VI, figs. 2-2b; Plate XXVI, fig. 5.

Amplexopora multispinosa Cumings, 1901, Am. Geol. XXVIII, p. 376, pl. xxxiv, figs. 7-10.

"Zoarium consisting of frequently branching cylindrical or sub-cylindrical stems of an average diameter of from 8 to 10 mm. Surface with inconspicuous maculae. Cells of average size about 0.2 mm. in diameter.

"In longitudinal sections the cells are seen to be thin-walled in the axial region and without diaphragms. They bend somewhat abruptly toward the surface, becoming greatly thickened and at the same time developing in the passage from the immature to the mature region a considerable number of diaphragms, many of which are curved or even coalesce, giving the false appearance of cystiphragms. Near the surface diaphragms are again lacking.

"In tangential sections, cutting the mature region, the cell-walls are thick, with very clearly defined true walls thickly interspersed with small acanthopores and covered by a copious deposit of secondary sclerenchyma."—Cumings, *loc. cit.*

This form is very close to *A. septosa* and is not considered by Bassler as distinct from that species. The examination of a considerable number of specimens, however, from a number of localities has convinced me that there are rather constantly two groups of the *A. septosa,* one in which the walls are conspicuously indented by the acanthopores (the typical *A. septosa*) and one, the present form, in which the walls are seldom indented. It has seemed to me, therefore, wise to retain the name *multispinosa* as a varietal designation. Besides Milton and Vevay, Indiana, the form occurs in the Tanner's Creek section.

1.34C8, 13....1.38A24-32....1.35C5.

AMPLEXOPORA FILIASA.

Plate V, fig. 2; Plate VII, figs. 1-1b.

Amplexopora filiasa Ulrich and other American authors (not d'Orbigny). For figures of this form see Ulrich, Geol. Ill. VIII, pl. xxxvi, figs. 7, 7a.

I am at a loss to whom to credit this species. That it is not the *Monticulipora filiasa* of d'Orbigny is shown by the figure of a thin section recently published in the Annales de Paleontologie (Tome II, Fasc. II). The figure referred to suggests *Monticulipora epidermata* Ulrich and Bassler, although M. Thevinin (*loc. cit.*) suggests *Prasopora falesi* James. I cannot determine from the figure published by Thevinin whether his reference is correct or not, in as much as the wall structure cannot be made out from the figure. At all events *M. filiasa* d'Orbigny is certainly not the same as the species commonly referred to it in this country. Whether Edwards and Haime had the same species as the one figured by Thevinin, cannot be determined from their meagre description. Nicholson evidently had the form now commonly known as *Amplexopora filiasa,* and if that is the case should probably be credited with the species. This point cannot be settled, however, until Edwards and Haime's type is investigated. Very probably d'Orbigny's type set of specimens contained several species. Whether d'Orbigny indicated any particular specimen as the type, or, if not, upon what basis M. Thevinin made his selection of the type, I do not presume to say.

The form commonly known in this country as *Amplexopora filiasa* is a massive species, sometimes attaining a diameter of several inches, and more or less lobate. The surface is covered with rather small monticules and the zooecia are regularly polygonal, and without mesopores. Internally the zooecia are thin-walled, even in the mature region, acanthropores are few and small, and the zooecia are crossed by straight diaphragms, from less than a tube diameter to several tube diameters apart, and present in the immature as well as the mature region. The wall structure is as in other species of *Amplexopora.*

This species is not uncommon near the top of the Lorraine.

1.38P.

ARTHROPORA CLEAVELANDI (James).

Plate XXVI, fig. 10.

Ptilodictya cleavelandi James, 1881, The Paleontologist, No. 5, p. 38. (Not figured.)

"Polyzoary, so far as observed, consisting of slightly oval, or flattened two-edged fronds, about half a line wide, and ¼ to ½ an inch long. Giving off short lateral branches, varying from nearly right to acute angles, from half a line to one line apart, arranged, generally, in an alternating manner, but in some cases opposite to each other. Fronds celluiferous on both sides, with five or six rows on each face of the main stem, of oval, or sub-circular cells, arranged alternately, and four or five rows on the branches. No elevated or dividing line at the lateral margins of the fronds, as in some other species of this genus. Four or five cell apertures, in the space of half a line, measuring diagonally across the frond. The best preserved specimens show the cell walls as distinct, and a depressed, sinuous line between, with the margins of the cell mouths slightly raised. Internal structure not observed.

"This species bears some resemblance to *Pt. shaferi*, Meek (Pal. of O., vol. 1, p. 69, pl. 5), but differs materially in the *rounded, non*-striate, instead of flat, sharp *striate* edges of the fronds of that species; and the single depressed line between the cell apertures, instead of a striate surface."—James, *loc. cit.*

This species, according to Bassler (James Types, p. 14), is characterized by slender generally non-bifurcating segments, and by the numerous and small lateral branchlets springing out at nearly right angles from the main stem. According to the same author *Ptilodictya grahami* James and *Ptilodictya dubia* James are synonyms of *Arthropora cleavelandi.*

1.34C8, 9, 10, 11.

ARTHROPORA SHAFFERI (Meek).

Plate XXVI, fig. 9.

Ptilodictya (*Stictopora*) *shafferi* Meek, 1872, Proc. Acad. Nat. Sci. Phila. (February, 1872), p. 317. (Not figured.)

"Polyzoum small and delicate, consisting of slender, compressed divisions, that give off on each side rather closely arranged, regularly alternating, lateral branches of the same breadth as the main stems, from which they diverge at an angle of about forty degrees; lateral branches in the same way giving off on each side very short lobe-like, alternating projections; lateral margins of all parts very narrow, sharp, and minutely striated longitudinally, in well-preserved specimens; pores apparently without raised margins, more or less oval longitudinally, alternatly disposed in longitudinal and oblique rows, so as to present a quincuncial arrangement; the number of longitudinal rows varying from five to about seven in the breadth of a stem or branch; spaces between the pores, measuring transversely to the stems and their divisions, about equal to the breadth of the pores, but greater, measuring in the direction of the oblique and longitudinal rows; all the interspaces ornamented, in perfectly preserved specimens, by very minute, more or less waved or flexuous striae.

"Size of entire polyzoum unknown; breadth of stems and branches, 0.05 inch; number of pores in 0.05 inch, measuring in the direction of the oblique rows, about 4 to 6, and, in the same space, measuring longitudinally, from 3 to 4.

"This very delicate little form will be readily distinguished from the other known Silurian species by its small size and peculiar plumose mode of growth, and particularly by its very minute striae between the pores. *Stictopora raripora,* Hall, from the Clinton group of New York, is as delicate a form, but differs materially in its mode of growth, and particularly in its very much less numerous pores.

"The specific name is given in honor of Mr. D. H. Shaffer, of Cincinnati, Ohio, to whom I am indebted for the use of a very fine specimen of it; I also have good specimens from Mr. Dyer's collection."—Meek, *loc. cit.*

The above description, together with the figure given herewith, will make the identification of this fairly abundant species easy.

1.33A3....1.34C13, 14b....1.34A1, 3, 7, 8, 14b, 15a, 16, 17, 18b, 19-21, 20, 21....1.34B1-3, 4-5....1.41A4, 5, 6, 9, 10a, 10b.... 1.41B1, 2, 3....1.41C1, 2, 3....1.41D1, 2, 3....1.41E3, 6.... 1.12A2....1.12E3....1.12F3....1.12D1-6.

ARTHROSTYLUS TENUIS (James).

Plate XXVI, figs. 8-8c.

Helopora tenuis James, 1878, The Paleontologist, No. 1, p. 3.

"Polyzoary minute, consisting of straight, angular or cylindrical stems, with a single row of cells on the face exposed; cell apertures oblong, with raised margins, arranged between strong longitudinal lines, and separated about the distance of their longer diameter; about 6 cells in the space of a line, including the interspaces. Examples examined are unbranched, from 1/4 to 1/2 an inch long, and 1/8 to 1/10 of a line in diameter.

"Some specimens have a depressed line on the highest part and a row of much raised oblique cell mouths on each side—others show only striated faces, no cells; and some have swollen terminations. All examples observed lie upon the surfaces of other substances, no detached specimens found, consequently but one face of any *one* example can be seen."—James, *loc. cit.*

The following corrected description is given by Bassler (1906): "The zoarium is jointed, but specimens showing the segments still in connection are not common. The segments are very slender, straight, needle-shaped rods, about 5 mm. in length, slightly expanding toward the obtusely rounded upper extremity. The latter articulates with the pointed lower ends of generally two succeeding segments, the complete zoarium appearing to consist of extremely delicate and regularly bifurcating branches. Cross sections of a segment are subquadrangular in shape, three of the sides being concave and equal in width, while the fourth side is slightly convex and half again as wide. Each of the three equal sides bears a row of zooecia, while 6 to 8 longitudinal striae mark the fourth side. The zooecial apertures are oval, and when perfect have a delicate and prominent equally elevated rim; 9 zooecia in 2 mm."

According to Bassler this species is not uncommon throughout the Eden shales. The types are from the lower division at Cincinnati, Ohio.

1.34C8, 9.

ATACTOPORELLA MULTIGRANOSA Ulrich.

Plate VII, figs. 2, 2a.

Atactopora multigranosa Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 122, pl. xii, figs. 1-1b.

"A parasitic bryozoan, attached to species of *Orthoceras*; growing in large, thin expansions, frequently in superposed layers, and more developed in certain portions than in others; greatest thickness of any crust observed about three-fourths of a line. Surface presenting numerous, irregularly distributed monticules, which sometimes have a portion of the summit compact, but usually the entire macula is composed of an aggregation of larger-sized tubes than the average; the height and diameter of the tubercles vary, but their average dimensions are about one-quarter of a line in height by one-half a line in diameter. With the aid of a magnifier the entire surface is seen to be covered with minute granules; they are so numerous that in well-preserved specimens the outlines of the tube orifices cannot be traced. Tubes small, rather thin-walled, of unequal sizes, from ten to fourteen of those situated between the monticules, occupying the space of one line, without any minute interstitial tubuli. Tube mouths polygonal or floriform, their margins carrying a row of inwardly projecting, minute tubercles or granules.

"From *A. hirsuta* this species is distinguished by its more profusely granulated tube walls, groups of larger sized calices, and in the less compact monticules. The growth of *A. multigranosa* is peculiar, being very irregular, in consequence of a greater development at some parts of the colony than at others; in *A. hirsuta* the thickness of the expansion is nearly equal in all parts. In *A. ortoni*, Nicholson, there are no groups of larger sized tubes, the monticules are conical, and regularly arranged."—Ulrich, *loc. cit.*

Middle Lorraine.

ATACTOPORELLA MUNDULA Ulrich.

Plate VII, figs. 3, 3a; Plate XXVI, fig. 6.

Atactopora mundula Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., vol. II, p. 123, pl. xii, figs. 4, 4a.

"Bryozoary parasitically attached to the fronds of *Chaetetes* (*Monticulipora*) *mammulatus* [*Heterotrypa frondosa* ?]; grows in thin expansions of less than one inch in diameter; thickness less than one-half a line. Surface at regular intervals raised into rather prominent tubercles, placed a little more than one line apart (measuring from center to center), and arranged in diagonally intersecting lines; surface of monticules occupied by calices of the ordinary size. Tubes polygonal, with thick walls, the interstitial spaces occupied by numerous minute tubuli, that are best observed in worn specimens. Tube mouths small, of very irregular shape, but of nearly equal size, ten to twelve in the space of one line; Pseudo-septa well developed, varying from two to five in each tube. No spines nor granules appear to have been developed; the superior ends of the septal ridges, however, sometimes are a little prominent, and thus simulate spines.

"Although closely related to *A. ortoni,* Nicholson, this species has certain characters by which it can be easily distinguished from that form. In that species the walls of the tubes are rather thin and granulated, and there are no true intertubular cells, while in *A. mundula* the walls are thick, not granulated, and are provided with numerous interstitial cells. The monticules are larger and not compact as they are in *A. ortoni.* Worn examples of *A. multigranosa* bear some resemblance to this species, but the thinner walls, non-tubular intercellular spaces, irregular growth and disposition of the maculae in that species will serve to distinguish them."—Ulrich, *loc. cit.*

I have one good specimen of this species, figures of which I give.

1.33A3.

ATACTOPORELLA NEWPORTENSIS Ulrich.

Plate VII, fig. 4; Plate XXVI, fig. 7.

Atactoporella newportensis, Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., vol. VI, p. 250, pl. xii, figs. 4-4b.

"Zoarium robust, growing upon foreign objects, lobate, or throwing off subramose shoots. At intervals of about .12 of an inch, measuring from center to center, the surface is elevated into more or less prominent, rounded, and often elongated monticules, the summits and slopes of which are occupied by cells a little larger than the average. Cells rather regularly arranged in intersecting series, from eleven to thirteen of the ordinary size in the space of .1 inch, with subcircular or ovate apertures, having an average diameter of 1/150th of an inch. On finely preserved examples the apertures are surrounded by a slightly elevated rim or peristome, which is often a little inflected at the points occupied by the numerous, though very small, spiniform tubuli. Interstitial cells numerous, but as usual with species of this genus, they are not readily detected externally.

"Internally this species is in many respects precisely like *A. typicalis*. In tangential sections the cells are seen to be somewhat unequal, narrower, the walls less inflected, and the spiniform tubuli smaller than in that species. Externally they differ in their surface markings, the zoarium of *A. typicalis* being prevalently entirely smooth, while that of *A. newportensis* is generally strongly tuberculated, besides being of more robust growth. The cell apertures also are never so distinctly petaloid as in the type species." —Ulrich, *loc. cit.*

Lower Eden.

ATACTOPORELLA ORTONI (Nicholson).

Plate VII, figs. 5, 5a; Plate XXVI, fig. 11.

Chaetetes ortoni Nicholson, 1874, Quar. Jour. Geol. Soc. London, XXX, p. 513, pl. xxix, figs. 15-15b.

"Corallum forming exceedingly thin crusts, not more than from one-sixth to one-eighth of a line in thickness, attached parasitically to submarine objects. Crusts usually constituting small circular expansions, or irregular and indefinite in form. Surface exhibiting numerous, minute, rounded or obtusely conical eminences, which are placed at intervals apart of a half a line, more or less. The tubercles are somewhat compact at their summits, and carry upon their sides corallites which are a little or not at all larger than the average. The corallites are somewhat oblique to the surface, moderately thick-walled, subequal, without any minute intercalated tubuli. Calices small, subpolygonal or oval, from ten to twelve in the space of one line; their margins thick and surmounted by minute and crowded miliary granules, which are rounded and not spinous, and which are placed almost in contact with one another.

"In appearance, this species, but for its extreme thinness and the small close-set surface-turbercles, might be confounded with *C. papillatus*. On examination with a high power, however, it is readily distinguished from all the known incrusting species of *Chaetetes* by the fine and close granulation of the margins of the calices, giving to the surface quite a peculiar appearance. All the specimens I have seen of this singular species are parasitic upon *Strophomena alternata*; and I am informed by Mr. James that it is rarely found attached to any thing else. In spite of the granulated margins of the calices, it appears to be a genuine *Chaetetes,* and I see no reason for removing it from this genus.

"I have named the species after my friend, Prof. Edward Orton, of the Geological Survey of Ohio, from whom, as well as from Mr. U. P. James, I have received the specimens from which the above description is drawn."—Nicholson, *loc. cit.*

According to Ulrich, who has carefully investigated the internal characters of this species, tangential sections show that the somewhat petaloid zooecia are separated from each other by an extensively developed series of rather large angular mesopores. In most sections taken near the surface these interzooecial spaces appear solid, and it is only occasionally that the mesopores can be certainly identified. Each zooecium is surrounded by a circle of medium-sized acanthopores, and it is the projecting ends of these at the surface that gives to the latter its strikingly hirsute appearance. In vertical sections it is shown that the zoarium may consist of several superimposed layers. The zooecia rise rather abruptly from the substratum and proceed directly to the surface. They are occupied by a series of cystoid diaphragms, and by a smaller number of straight diaphragms. In the mesopores the diaphragms are numerous.

This species is not uncommon near the top of the Lorraine.

1.33A3....1.34B1-3....1.12A2....1.38Bb, c, d.

ATACTOPORELLA SCHUCHERTI Ulrich.

Plate VII, figs. 6, 6a.

Atactoporella schucherti Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., vol. VI, p. 251, pl. xii, figs. 5-5b.

"Zoarium parasitically attached to shells and other foreign bodies, over which it forms thin irregular expansions, usually less than an inch in diameter, and rarely more than .03 of an inch in thickness. The surface generally exhibits at intervals of .1 inch or more slightly raised eminences. When in a good state of preservation the cellular structure is almost entirely obscured by the innumerable surface extensions of the large spiniform tubuli, in many of which the perforation at the apex is clearly shown. When worn, the cell apertures are rounded, about ten in .1 of an inch, with thick interspaces, occupied by the shallow calices of numerous interstitial cells, which in old examples are not readily detected.

"The distinctive characters of the species are well brought out in tangential sections. The cell walls are thin, and between the numerous and large spiniform tubuli are of about equal thickness throughout. Excepting when the section cuts the zoarium just beneath the surface, it is difficult to discriminate between the interstitial cells and true zooecia. But, when near enough to the surface, the former are mostly filled with transparent calcite, while the latter are filled with particles of the surrounding matrix, and when this fails they may be more certainly distinguished by the possession of the crescentic edges of the cystoid diaphragms. The interstitial cells are numerous, but very unequal in size; as a rule, they completely isolate the true cells. The arrangement, size and character of the spiniform tubuli are well shown in the figures referred to.

"In vertical sections, unless they follow the direction of the growth of the colony, the same difficulty of distinguishing the interstitial from the true cells in experienced. This is mainly due to two reasons: First, the cystoid diaphragms, a series of which is apparently developed in each of the proper zooecial tubes, are always attached to the concave side of the tube, and unless the section passes along the direction of growth, these diaphragms present the same appearance that those of the ordinary straight kind do. Secondly, we find that the horizontal diaphragms of the interstitial tubes are but little, if at all, more numerous than the cystoid diaphragms of the true zooecia. There is one feature, however, by means of which I believe the two sets of tubes may be at all times distinguished, namely, the interstitial tubes are crossed by diaphragms at regular intervals throughout their length, while the true cells, near their apertures, are always filled by the surrounding matrix. The spiniform tubuli are very conspicuous in these sections, and nearly always show the central lucid line, which in several instances appears to be crossed by numerous horizontal partitions.

"This species differs from all the others of the genus known to me in the size and prominence of the spiniform tubuli. Compared more critically with *A. mundula* we find the following differences. In that species the spiniform tubuli are considerably smaller, and less prominent, the intertubular spaces narrower, and, in consequence the interstitial cells smaller and less numerous, while the diaphragms in the interstitial tubes are about twice as numerous in a given space.

"Named in honor of my esteemed friend, Mr. Charles Schuchert, who kindly gave me, among other interesting forms, a large and most beautifully preserved example of this species."—Ulrich, *loc. cit.*

1.33A3 (?)....1.41E6....1.12A2.

BATOSTOMA IMPLICATUM (Nicholson).

Plate VII, fig. 7; Plate VIII, fig. 2.

Monticulipora (*Heterotrypa*) *implicata* Nicholson, 1881, Genus Monticulipora, p. 147, pl. ii, figs. 7-7e; and fig. 27, p. 148.

"*Spec. Char.*—Corallum dendroid, of small flattened stems, which average about three lines in width, and from a line and a half to two lines in thickness, giving off branches at short intervals. The calices are mostly about 1/70th to 1/80th inch in diameter, irregularly oval, often indented on one or both sides, thick-walled, with numerous blunt spines projecting from their margins. Between the ordinary calices are the occasional apertures of smaller tubes. The average corallites are thin-walled in the center of the corallites, but become greatly thickened as they approach the surface, the original lines of demarkation between adjoining tubes being never entirely obscured. Smaller corallites are developed in variable number between those of average dimensions. Interspersed also in the thickness of the walls of the corallites, or occupying their angles of junction, are numerous circular hollow tubes, the upper terminations of which appear on the surface as the blunt spines previously alluded to. Remote, complete, and approximately horizontal tabulae are developed in the tubes, being somewhat more numerous in the small corallites than in the large ones.

"*Obs.*—Not having met with any published account of this species, I am not sure that it has been actually described by Mr. Ulrich, to whom we already owe so much excellent work on the fossils of the Cincinnati Group; but it has been named by him in his catalogue of the Fossils of the Cincinnati Group, and Mr. Nickles has been good enough to present to me some specimens of it. Under the circumstances, I should not have been justified, perhaps, in treating of it at all in this place; and my only apology for giving even the above short description of its characters is, that it possesses a structural feature which I should have felt unwilling to have passed over without notice. It illustrates, namely, in a remarkable manner, those peculiar structures which occur in so many of the *Monticuliporae* and *Stenoporae,* and which I have termed 'Spiniform corallites' [now known as Acanthopores]. Thus, if we examine a tangential section, we observe at the angles of junction of the normal corallites, or between the thick walls of two adjoining tubes, a number of clear circular spaces of comparatively large size (from 1/500th to 1/450th inch in diameter). Some of these clear spaces preserve the same character throughout, but most of them exhibit centrally either a dark spot or small, clear ring. These spaces are, therefore, clearly sections of tubes, and there can be no doubt that the spines which stud the thick walls of the calices are the upper terminations of these same tubes. I have not succeeded in detecting any opening at the apices of these spines, though their tubular nature would lead one to expect that such must exist. I have, however, I think, succeeded in satisfying myself that their cavities, as seen in long sections, are crossed by distinct horizontal *tabulae.* This is a point of importance, as tending to confirm my views that these hollow spines, in this and in the many other cases in which they occur, are really of the nature of very peculiarly modified and specialized corallites."—Nicholson, *loc. cit.*

This well-marked species, which Nicholson has very adequately described, is common in the Utica formation wherever exposed. It can readily be distinguished from *B. jamesi,* when well preserved, by the markedly spinose exterior and the small number of mesopores. Internally, it differs in several characters from the latter species: in the greater thickness of the zooecial walls, the smaller number of mesopores, and the large size of the acanthopores, and in the fact that these structures commonly indent the zooecia, giving the latter a more or less irregular shape.

5.9A6, 14, 21, 31, 29....1.34Co, 5, 6, 7, 8, 9, 13....1.38A9, 11, 13, 17, 23, 24, 31, 32, 33, 37.

BATOSTOMA JAMESI (Nicholson).

Plate VII, figs. 8, 8a; Plate VIII, fig. 1; Plate XXVII, figs. 6, 6a.

Chaetetes jamesi Nicholson, 1874, Quar. Jour. Geol. Soc. London, XXX, p. 506, pl. xxix, figs. 10-10b.

"Corallum of cylindrical or subcylindrical hollow branches, the diameter of which is from 3 to 5 lines; or of somewhat lobate and subpalmate masses, the extremities of which are rounded. Branches in the ramose forms dividing dichotomously at irregular intervals, irregularly thickened and nodulose. Corallites oval or circular in section, of unequal sizes. The larger corallites about six in the space of one line, with very thick walls, the margins of the round or subpolygonal calices being obscurely tuberculated or granulated. The larger corallites are separated by extremely minute cylindrical tubuli, the number of which varies in different parts of the corallum. The surface exhibits no eminences or tubercles, or groups of large-sized corallites, but typical specimens exhibit at irregular intervals stellate spaces, which are either solid or minutely punctate, and have a diameter of two-thirds of a line.

"This species is related to *Chaetetes tumidus,* Phill., of the Carboniferous rocks, especially in the rounded, thick-walled corallites, separated by minute intermediate tubes. I have, however, compared it with specimens of the latter, and find it to be clearly distinguished by the larger size and much thicker walls of the corallites, the generally greater number of the minute intermediate tubules, the tuberculated margins of the calices, and the existence of the curious stellate, solid or porous interspaces. The value of this last character is diminished by the fact that some specimens, otherwise the same, do not exhibit these spaces in a conspicuous manner. The tuberculated margins of the calices, though this feature can only be detected with the use of a high magnifying power, remind one of the species generally considered as belonging to the genus *Stenopora.*"—Nicholson, *loc. cit.*

This well-marked species does not possess hollow stems, as stated above; Nicholson's mistake probably being due to his seeing specimens in which the axial region had disappeared through weathering. The rather small rounded stems and large oval zooecia with a well developed series of mesopores are the chief superficial characters of this species. Internally it presents the characteristic structure of the genus *Batostoma.* In tangential sections cutting the mature region the walls are seen to consist of rather thick dark rings of dense sclerenchyma, those of neighboring zooecia generally widely separated from each other, though occasionally in contact, and the intervening space occupied by angular and irregularly shaped mesopores. Imbedded in these walls or occupying the line of contact of the walls of adjacent zooecia are numerous rather small acanthopores. The projecting ends of these upon the surface of the zoarium give it, in well preserved specimens, a minutely spinose or granular appearance. In longitudinal sections the zooecia are seen to be crossed by rather infrequent complete diaphragms. In the mesopores these are four or five times as abundant as in the zooecia. The walls in the axial region are thin and the zooecia polygonal in shape. This species differs from the associated *B. implicatum* in the greater development of mesopores, the more nearly circular shape of the zooecia, the smaller size of the acanthopores, the less thickness of the walls, and superficially in the fact that *B. implicatum,* when well preserved, presents a decidedly spinose appearance owing to the great number of large acanthopores.

5.9A2....1.34Co, 5, 6, 7, 8, 9, 10, 11....1.38A7.

BATOSTOMA VARIABILE Ulrich.

Plate VIII, fig. 4; Plate XXVI, fig. 13.

Batostoma variabile Ulrich, 1890, Geol. Illinois, VIII, p. 460, pl. xxxv, fig. 5; xxxvi, fig. 1 (not pl. xxxv, figs. 4b-4e=*B. varians* (James)).

"Zoarium exceedingly variable; encrusting, lobate, digitate, ramose and subfrondescent. Surface smooth, showing inappreciably elevated clusters of larger cells. Walls of zooecia 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 zooecia.

"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 zooecia separated by many mesopores, while this species has the zooecia polygonal and often in contact, with fewer mesopores and diaphragms."—Ulrich, *loc. cit.*

This is the original description by Ulrich, which has been found to include, according to Bassler,* two good species, one of which is the *B. varians* James sp., a species having a different range, being found abundantly in the lower and middle Richmond, while *variabile* as restricted by Bassler (*loc. cit.*) is confined to the uppermost beds of that formation.

*Proc. U. S. National Museum, vol. XXX, 1906, pp. 18, 19.

The following is Bassler's description of *Batostoma variabile* as restricted:

"*B. variabile,* as thus restricted, forms robust, cylindrical or subcompressed, usually infrequently dividing stems, 10 mm. or more in diameter. The surface of the zoarium is smooth, but maculae of conspicuously larger zooecia are present. The zooecia are thin-walled and angular at the surface with mesopores practically absent. Below the surface the zooecial walls are so thickened by deposits of tissue along their sides that a tangential section through this region gives a rounded aspect to the apertures. Six to seven of the ordinary zooecia occur in 2 mm. Acanthopores sometimes large and occupying all the zooecial angles, but at other times not a conspicuous feature. Distribution of diaphragms and other internal features as shown on Plate VII [of Bassler's paper].

"Because of the absence of mesopores, this species shows with unusual distinctness in tangential sections, the black line separating the walls of continguous zooecia, a characteristic feature of this as well as a number of other genera of the Monticuliporoids. The large, smooth, ramose zoarium, angular contiguous zooecia, few mesopores, and conspicuous clusters are characters sufficient to distinguish this form from other species of the genus.

"The specimens figured by Ulrich from the Richmond group at Savannah, Illinois, cannot be determined with certainty on account of their ill-preserved internal structure, but it is probable that they belong to neither of the two species under discussion."
—Bassler, *loc. cit.*

I have referred but a single specimen to this species, namely one from Madison, Indiana, from the beds immediately underlying the Saluda formation.

1.12D1-6.

BATOSTOMA VARIANS (James).

Plate VII, fig. 9; Plate VIII, figs. 3-3b; Plate XXVI, fig. 14.

Chaetetes varians James, 1878, The Paleontologist, No. 1, p. 2. (Not figured.)

"A coral resembling *Chaetetes jamesi,* Nicholson, is found in the upper beds of the *Cincinnati group.* Its mode of growth seems to differ in some respects, being spread over shells, in thin lays, in some cases; in others, branching out in a digitate manner from lobate, palmate and irregular-shaped forms; the average calices are scarcely as thick walled as typical *Jamesi,* and the stellate spaces rather more conspicuous. Should it prove a distinct species, I propose for it the name *varians* (Chaetetes varians).''—James, *loc. cit.*

In the large size of the zooecia, peculiar appearance and number of the acanthopores, and in the wall structure this species is quite similar to *B. jamesi* of the Eden formation. It differs from that species, however, in the slight development of mesopores in *B. varians,* while they are very abundant in *B. jamesi,* and in the polygonal shape of the zooecia and usually irregular form and larger size of the zoarium of *B. varians.* This species is very abundant in the Waynesville division of the Richmond formation. It is also found in the Arnheim division and sparingly in the Liberty division. It can usually be recognized at a glance by its unusually large zooecia, though in this respect it might be confused with the associated *Rhombotrypa quadrata,* which can, however, be readily distinguished by the rhombic zooecia nearly always to be seen at the ends of branches.

1.34A10, 11, 12, 13, 14b, 15a, 16, B4-5....1.41B1, 2, C2-3, D1, A5, E3....1.12E3.

BERNICEA PRIMITIVA Ulrich.

Plate XXVI, fig. 12.

Bernicea primitiva Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., vol. V, p. 157, pl. vi, fig. 4.

''Zoarium attached to foreign bodies, and forming small subcircular or irregular patches. Cells small, mostly immersed, somewhat irregular in their arrangement, with the rounded and slightly oblique apertures raised conspicuously above the general surface. Cell apertures usually about twice their own diameter distant from each other; about eight occupy the space of .1 inch.''—Ulrich, *loc. cit.*

The general aspect of this species is very similar to *Proboscina,* from which it differs in the fact that it forms expansions which are continuous rather than reticulated, as in the latter genus.

Several good specimens were obtained from the Richmond formation.

1.41B1....1.12E3.

BYTHOPORA ARCTIPORA (Nicholson).

Plate VIII, fig. 8; Plate XXVI, figs. 15, 15a.

Ptilodictya (?) *arctipora* Nicholson, 1875, Ann. Mag. Nat. Hist., 4th ser., XV, p. 180, pl. xiv, figs. 4-4b.

"Polyzoary forming a cylindrical, slightly branched frond, which is not sharp-edged, exhibits no non-celluliferous borders, and shows no traces of a central laminar axis. Cells arranged in obscurely longitudinal alternating rows, apparently perpendicular to the surface, and radiating in all directions from an imaginary axis. Cell-mouths very much compressed, much longer than wide, expanded below and attenuated superiorly, where they are often much twisted and bent. Upon the whole, the cells are pyriform in shape, with their narrow ends directed upwards, about eight occupying the space of one line measured vertically, and twelve the same space measured diagonally. The cells are not always in contact, especially in their upper portion; and their borders are always distinctly marked off by impressed lines; but they are not arranged between elevated longitudinal ridges. The margins of the cells are very thick and conspicuous, not granulated, tuberculated, or spinigerous.

"The best-preserved fragment examined had a length of eight and a half lines, dividing at its summit into two branches, its diameter being rather more than one-third of a line.

"From its cylindrical form, and the absence of a laminar axis or of non-poriferous margins, it would seem certain that this singular form is not a *Ptilodictya*; but I am at a loss to know where it should properly be placed, its extreme minuteness rendering its generic affinities very uncertain, owing to the impossibility of making out the details of its internal structure. It has, however, some affinity with *Ptilodictya* (?) *raripora,* Hall, from the Clinton Group, and I have therefore referred it provisionally to this genus."—Nicholson, *loc. cit.*

There is nothing particularly characteristic in the internal structure of this species. It is a typical *Bythopora.* This is a common and characteristic species in the Eden shales.

5.9A2, 6, 8, 10, 21, 29, 31, 35....1.34C5, 6, 8, 9, 10, 11.... 1.38A5, 11, 13, 15, 17, 19, 21, 23, 24, 32, 33, 41.

BYTHOPORA DELICATULA (Nicholson).

Plate VIII, fig. 7; Plate XXVII, fig. 1.

Chaetetes delicatulus Nicholson, 1874, Quar. Jour. Geol. Soc. London, XXX, p. 505, pl. xxix, figs. 8-8b.

"Corallum very slender and delicate, ramose, composed of cylindrical stems, terminating in rounded, sometimes thickened extremities, and apparently springing in some cases from a horizontal footstalk. Stems sometimes apparently simple, more commonly branched dichotomously, the division taking place at acute angles; diameter of the stems and branches from one-quarter of a line to half a line, rarely reaching two-thirds of a line. Corallites very oblique to the surface, opening by oval apertures, the length of which corresponds with the axis of the stem and exceeds the breadth. Calices in diagonal rows, about eight in 1 line measured longitudinally, and from twelve to fourteen in the same space measured diagonally. When perfect and unworn, the lower lip of the calices is thin and prominent. The calices are all of equal size, and the surface is destitute of monticules or tubercles.

"This is one of the commonest fossils of the Hudson River formation, both in Canada and the United States. From its very minute size, I am left somewhat uncertain as to the true position of this abundant little fossil. It is, I think, certainly the form which has generally been quoted as a slender variety of *Stenopora fibrosa*; but even if this species were to be retained, our examples could not be placed under it. It is likewise apparently one of the forms which has been figured by Hall under the name of *Chaetetes lycoperdon* (Pal. N. Y. vol. i, pl. 24, fig. 1*k*, caet. excl.). It is most closely allied to *Chaetetes gracilis*, James, but it is readily separated by the absence of minute tubuli interspersed amongst the larger corallites, by the much greater obliquity of the corallites and their much thinner walls, and by the uniformly slender habit and stunted growth. From *C. fletcheri*, Edw. & H., it is also distinguished by the size of the corallites and their oblique direction.

"Of the fossils of the later rocks, *C. delicatulus* runs a considerable chance of being confounded with *Helopora fragilis*, Hall, which it much resembles superficially. It is, however, readily distinguished by its almost always being branched, by the form of the calices, and by the fact that the calices are not arranged between longitudinal elevated lines."—Nicholson, *loc. cit.*

The above description indicates very well the external features of this species. Internally it does not differ materially from *B.*

gracilis, except in the absence of mesopores and diaphragms. It is abundant at several levels in the Richmond formation.

1.34B4-5....1.34A3, 4, 8, 9, 10, 14b, 15a, 15b, 16a, 16b, 17, 18a, 19-21, 22, 23....1.41E2, 3, 4, 5....1.41A5, 6, 9, 10a, 10b.... 1.41D1, 2, 3....1.41B1, 2, 3....1.12F3.

BYTHOPORA GRACILIS (Nicholson).

Plate VIII, figs. 6-6b; Plate XXVII, figs. 2, 2a.

Chaetetes gracilis Nicholson, 1874, Quar. Jour. Geol. Soc. London, XXX, p. 504, pl. xxix, figs. 7, 7a. (Named, but not described or figured, by James, 1871, Cat. Foss. Cin. Group.)

"Corallum dendroid, the branches cylindrical or subcylindrical, from less than 1 line to 2 lines in diameter, dividing dichotomously at short intervals. Corallites very small and crowded, from ten to twelve in the space of 1 line, thick-walled, opening obliquely on the surface by oval or circular calices, between which are placed excessively minute circular tubuli. The surface exhibits no elevations or tubercles, but is entirely smooth; and there are also no groups of larger-sized corallites, the ordinary corallites being all nearly of a size.

"This species is allied to *C. fletcheri,* Edw. & H., from which it is distinguished by the thick-walled nearly equal corallites, and the oblique and very small calices, the dimensions of which are much more minute than in the latter form. My description is drawn from type specimens furnished by Mr. U. P. James."—Nicholson, *loc. cit.*

The likeness to *Chaetetes fletcheri* E. & H., is only of the most superficial sort, and does not extend to any of the internal characters. Internally this species presents much the same characters as *B. meeki* and *B. delicatula,* from which it differs chiefly in point of size, being larger than the latter and smaller than the former. In the mature region the walls are very thick, and completely amalgamated, the lumen of the zooecium being always surrounded by a dark ring of dense sclerenchyma. The space between these dark rings is occupied by lighter colored, and evidently less dense material, in which are imbedded the moderately developed series of minute mesopores, and the still more minute thick-walled acanthopores. Carefully prepared sections show that the interzooecial walls are traversed by very minute punctae, apparently running at right angles to the direction of the zooecia. Whether these run through from one zooecium to another I have not been able to demonstrate.

In longitudinal sections the zooecia are seen to be crossed by an occasional diaphragm, and these are more numerous in the mesopores. The zooecia in the axial region have very thin walls and no diaphragms.

1.33A3....1.34A1 (?) .... 1.34B1-3, C14b .... 1.12A2 .... 1.38Bh....1.38P, and everywhere in the Upper Lorraine.

BYTHOPORA MEEKI (James).

Plate VIII, figs. 5, 5a; Plate XXVII, fig. 5.

Chaetetes meeki James, 1878, The Paleontologist, No. 1, p. 1. (Not figured.)

"In the upper beds of the *Cincinnati Group* I find a form of coral—abundant—much like *C. gracilis* in *general features,* the chief difference being in the larger size of the branches, some of them nearly one-half inch in diameter; the typical *gracilis averaging* not over one *line.* Should this prove distinct on further examination, I propose for it the name MEEKI (Chaetetes meeki) in honor of the late F. B. Meek."—James, *loc. cit.*

The internal characters of this species are identical with those of *Bythopora gracilis* (which see), for which reason Nicholson considers it as merely a variety of the latter. It has, however, a quite different range and is a considerably larger form, for which reasons I follow most recent students in considering it as a distinct species. It occurs in the Waynesville formation and is common in the Liberty formation.

1.34A8, 9, 11, 12, 13, 17, 19, 20, 21, 22, 23....1.41A4, 7, 8, B1, 2, D2, C1, E1, 2, 3....1.12D1-6, E3. F3.

BYTHOPORA PARVULA (James).

Plate XXVII, fig. 3.

Helopora parvula James, 1878, The Paleontologist, No. 1, p. 3. (Not figured.)

According to Bassler (James Types), "the zoarium of this species consists of very slender cylindrical branches, seldom exceeding 0.4 mm. in diameter, dividing at irregular, but very long intervals, and bearing four or five rows of elongate oval zooecia, rounded behind and drawn out in front, separated from each other longitudinally by spaces equal to their longer diameter. Measuring lengthwise about 5 zooecia in 2 mm. Narrow, channeled interspaces separate the rows of zooecia. Mesopores and acanthopores obsolete or apparently wanting. Diaphragms sparingly developed."

Distinguished from other species of Bythopora by its extremely slender branches and widely separated zooecial apertures. *B. arctipora,* an associated form, has larger branches and closer set zooecia.

Upper part of the Eden shale. My specimen is from Guilford, Indiana.

BYTHOPORA STRIATA Ulrich.

Plate XXVII, fig. 4.

Bythopora striata Ulrich, 1889, Cont. to the Micro-Paleontology of the Cambro-Silurian Rocks of Canada, pt. II, p. 36. (Not figured.)

"This name is proposed for a species represented in the Manitoba collections and sometimes found associated with *B. delicatula,* Nicholson, at Middletown and other localities in Ohio, where the upper beds of the Hudson River group are exposed. The branches of its ramose zoarium are usually more slender than those of that species, being rarely more than one millimetre in diameter. They also bifurcate at shorter intervals, the length of the latter varying between two and four mm. The apertures of the zooecia too, are more oblique and drawn out anteriorly, and are arranged between somewhat irregular rounded longitudinal ridges, with five or six in a space of two mm. long. Ten to fourteen of the ridges suffice to encircle a branch. These ridges are strongest near the base of the zoarium, gradually fading away toward the growing extremities of the stems.

"In *B. fruticosa,* Miller and Dyer, *B. arctipora,* Nicholson (species) *B. delicatula,* Nicholson, and other species known to me, an arrangement of the apertures of the zooecia in diagonally intersecting series prevails, while in *B. striata,* near its base at any rate, the longitudinal arrangement is the most conspicuous."—Ulrich, *loc. cit.*

As the original description of this species was not accompanied by a figure I am not altogether certain that I am correct in referring my specimens to it. I give a figure of the form which seems to me to correspond to Ulrich's description. It is a very minute species and not uncommon in the Richmond formation in association with *B. delicatula.* Some specimens show a striated base similar to that described by Ulrich.

1.34A7, 8, 9, 14a, 15b, 16b, 18, 19, 20, 21, 22....1.41A2, 4, 5, B1, 3, C1, 2-3, D1, 2, E6....1.12D1-6, F3.

CALLOPORA ANDREWSI (Nicholson).

Plate VIII, figs. 9, 9a; Plate XXVII, fig. 7.

Chaetetes pulchellus Nicholson (non Edwards and Haime) 1874, Quar. Jour. Geol. Soc. London, XXX, p. 503, pl. xxix, figs. 5-5b.
Monticulipora (*Heterotrypa*) *andrewsi* Nicholson, 1881, Genus Monticulipora, p. 128, pl. v, figs. 1, 1a; and fig. 21, p. 129.

"Corallum variable in form, usually of subcylindrical branches, which have a diameter of from 2 to 6 lines, sometimes forming flattened and expanded subpalmate fronds, sometimes inosculating. Corallites thin-walled, polygonal, unequal in size, about eight of the average ones occupying the space of 1 line. Surface exhibiting rounded or somewhat stellate groups of larger corallites, of which two or three occupy the space of half a line, and which sometimes have very minute intermediate tubuli between them. These groups of larger corallites generally comprise from five to seven individuals, and they are placed about 1 line apart; they are very slightly or not at all elevated above the general surface, so that there are no conspicuous tubercles.

"The characters of this species are so well marked as to render its recognition very easy, even in small fragments."—Nicholson, *loc. cit.*

Internally this species exhibits very beautifully the peculiar structure of the genus *Callopora.* Toward the surface the walls are much thickened and ring-like and are separated from each other by a set of small rounded mesopores. In longitudinal sections the zooecia and mesopores are seen to be crossed by a well developed series of straight diaphragms, which are very close together in the mesopores.

1.33A3....1.34B1-3, C14b.

CALLOPORA FRONDOSA n. sp.

Plate IX, figs. 1, 1a.

This species does not seem to differ materially in internal characters from the associated *C. subnodosa,* but it has a frondescent rather than a ramose or subfrondescent zoarium. The zooecia are a little larger than in *C. subnodosa* and the diaphragms a little less crowded.

1.41A6, E6.

CALLOPORA NODULOSA (Nicholson).

Plate IX, figs. 2-2c; Plate XXVII, fig. 8.

Chaetetes ? nodulosus Nicholson, 1874, Quar. Jour. Geol. Soc. London, XXX, p. 506, pl. xxix, figs. 9, 9*a*.

"Corallum dendroid, minute, of small cylindrical stems, which branch dichotomously at intervals of 2 lines, and have a diameter of from two-thirds of a line to 1 line. Corallites prismatic or hexagonal, directed somewhat obliquely to the surface, of two sizes. Larger corallites opening by subcircular or oval apertures, the long diameter of which coincides with the axis of the stems; from six to eight in the space of 1 line measured vertically. Smaller corallites in the form of minute circular tubuli interspersed amongst the larger tubes. Surface exhibiting numerous minute, sometimes conical, sometimes transversely elongated elevations or tubercles, which are placed at distances of about half a line apart, and give the surface a characteristic nodulose appearance.

"This very distinct species is more nearly allied to *C. dalei* than to any other; but it is very readily separated by its much more slender and graceful proportions, and the much smaller size of the proportionally remote tubercles. One specimen, indeed, which can hardly be referred elsewhere, exhibits on transverse section about twelve very distinct radiating septa meeting in the center of the corallites. Though all the other examples possess tabulae and have all the characters of *Chaetetes,* this raises the suspicion that possibly the form may require, on more extended investigation, to be removed from *Chaetetes.*"—Nicholson, *loc. cit.*

This species has the internal features characteristic of the genus *Callopora,* as shown in the figures published by Nicholson in the Genus Monticulipora, and reproduced herewith. It is a very small, slender form, occurring at a lower level than *C. dalei,* which it somewhat resembles.

5.9A6....1.34C8, 9, 10, 11....1.38A11 (?).

CALLOPORA ONEALLI (James).

Plate IX, figs. 3-3b; Plate XXVII, figs. 9, 10.

Chaetetes (?) *onealli* James, Catalogue of Lower Silurian fossils of the Cincinnati group, 1875, p. 2.

"Corallum dendroid; slender cylindrical branches, dividing, generally, dichotomously at irregular distances, and in some cases anastomosing; branches from half a line to two lines in diameter. Calices generally oval, but in some cases the variation may be from subcircular to polygonal, and from eight to ten in the space of a line, measuring lengthwise of the stem, varying considerably in size, occasionally one much larger than the average. Walls of corallites rather thick; minute tubes often between the apertures. The increase of corallites seems to be by fission. A cut section shows the stronger corallites as starting at the center, growing parallel with the length of the stem and following the direction and dividing with the branches, the outer ones curving to the surface obliquely, although the apertures appear to be direct." James, *loc. cit.*

According to the excellent description of Nicholson (Genus Monticulipora, p. 118), the species shows in tangential sections "that the corallum is composed of two distinct sets of corallites, large and small. The larger corallites are oval, about 1/100 inch, or rather less, in their long diameter, and, in this region, furnished with thickened walls. Each tube is surrounded by a ring-like wall of its own, and adjacent tubes are united to one another by sclerenchyma, in which run the numerous small corallites, these latter varying much in shape and size, but being usually sub-angular.

"Transverse sections show that in the central region of the corallum all the tubes are thin-walled and polygonal, only becoming thickened in the circumferential portion. Lastly, vertical sections show that the corallites in the axial region are not only thin-walled, but also remarkable in the shortness and slight curvature of their outer thickened portions. These sections also show that tabulae are nearly or quite absent in the center of the stems, but developed in fair numbers in the peripheral region, their direction, owing to the slight curvature of the corallites, being often nearly parallel to the outer surface. The small interstitial corallites are also seen to be provided with much more numerous and more closely-set tabulae than is the case in the large tubes. All the tabulae are, as a rule, complete, and horizontal or slightly curved; but in some cases a few of the tabulae in the throat of the large tubes may become so bent as to unite with one another, and to form a small number of lenticular vesicles in this region."

This form and *C. sigillaroides* seem to differ only in size—the latter form being a somewhat larger variety. *C. onealli* is common only in the lower member of the Eden Shales, though found sparingly at higher levels.

1.34Co, 7, 8, 10, 11....1.38A15, 37.

CALLOPORA ONEALLI var. COMMUNIS (James).

Plate VIII, fig. 10; Plate XXVII, fig. 11.

Monticulipora (*Heterotrypa*) *o'nealli* ? var. *communis* James, 1882, The Paleontologist, No. 6, p. 47, pl. i, fig. 8.

"Corallum, as generally found, much broken, cylindrical or subcylindrical stems from one to three lines in diameter, branching at variable distances in different directions at acute angles, but masses of considerable size—from one inch to six or eight inches or more in diameter—are sometimes found, in which the stems anastomose frequently in a very irregular manner. Most specimens exhibit masculae or 'monticules,' raised very little or none at all above the general surface, occupied by calices much larger than the average, and sometimes clusters of the smaller tubules. Calices generally oval or subcircular, occasionally somewhat angular; interstitial tubuli numerous, sometimes nearly or quite surrounding the larger cells, and of various shapes; an average of about six calices in the space of one line in the longitudinal direction of the stem, and seven or eight transversely. Apertures of cell walls thin at the surface of unworn specimens, but thickened immediately below, as shown by abraded examples, mostly found in that condition.

"In tangential section the cells are oval or subcircular, walls much thickened and distinctly defined by a dividing space, interstitial tubuli circular or angular. Section of a cylindrical stem, cut longitudinally, shows the corallites as very thin walled centrally, and taking a longitudinal direction with a very slight outward inclination till near the surface, where they make a decided curve and open obliquely. Tabulae remote in the axial part, none observed in the space of one-fourth of an inch in the example used for this description, but near the surface they become distinct, in some cases depressed or bent downward in the middle, or taking an oblique direction across the corallites; the smaller tubes are more closely tabulate. In a transverse section of the axial portion the tubes are thin walled, circular or angular, and occupied by cruciform dissepiments, the interstitial pores variable in shape.

"The interior structure of this species bears quite a close resemblance to M. sp. *o'nealli,* James, but the exterior differs materially, in being of a much more robust habit, in the maculae of larger calices, and groups of small pores. It is considered, by some, to be M. (Chaetetes) sp. *approximata,* Nicholson, but, clearly, it is not the form described and figured by Prof. N. as *approxi-*

matus in the 2d vol. of Ohio Paleontology, 1875, and again in his valuable work on 'Monticulipora,' 1881, where he gives it (approximata) as a synonym for M. sp. *ramosa*, var. *dalei*, E. & H."—James, *loc. cit.*

This variety is distinguished from *C. onealli* by its much larger branches and by the general absence of mesopores. For the internal characters the student is referred to the description of the latter species. In the var. *communis* the mesopores, which are present in deep sections, seem to pinch out as the surface is approached.

This variety is usually found in great numbers near the top of the Eden formation (Utica), being most abundant just below the zone of *Callopora dalei,* and associated with the latter in the lower part of its (*dalei*) range.

5.9A31....1.34C8, 9, 13, 14a....1.38A11, 13, 15, 21, 23, 24, 29, 31. A similar form was collected from the base of the Waynesville formation on Tanner's Creek (1.34A4).

CALLOPORA ONEALLI var. SIGILLAROIDES (Nicholson).

Plate IX, fig. 4.

Chaetetes sigillaroides Nicholson, 1875, Pal. Ohio, II, p. 203, pl. xxii, figs. 9, 9a.

"Corallum ramose, of small dichotomously dividing branches, the diameter of which is rather over one line. Calices regularly oval or sub-circular, their longer diameter corresponding with that of the stems, arranged in diagonal lines, about six in one line, measured diagonally, and from four to five in the same space, measured vertically. Between the average calices are a few minute sub-cylindrical tubuli. In the center of each calice, as a general rule, is a small, circular, secondary calice, about half the diameter of the main calice, and surrounded by a distinct wall, the general appearance of the calices thus somewhat resembling the markings of *C. sigillaria.* Walls of the corallites thin. Surface smooth, or with a few low, scattered, and irregular tuberosities, which in no way differ from the general surface, and always form a quite inconspicuous feature.

"As a general rule, fragments of this species can be recognized with the greatest ease by the peculiar appearance due to the existence of small circular calices within the main calices. In parts of some of the specimens, however, these secondary calices appear to be absent, and then the species is rcognizable by its large, oval, thin-walled calices, arranged in diagonal rows, and separated by minute tubuli, its smooth surface, and its small dimensions. Whether the appearance of secondary calices is due to the formation of perforated diaphragms over the mouth of the tubes at their final period of growth or not, I am not prepared to say."—Nicholson, *loc. cit.*

The opercular foramen (secondary calice of Nicholson) seen in this species is common to all species of the genus, but is perhaps rather more frequently seen in this than in other ordovician species. The opinion which Nicholson hints at that these "secondary calices" may be due to the formation of perforated diaphragms over the mouths of the ordinary calices, is now known to be precisely the true interpretation of these structures. In other words the zooecium is closed by a perforated operculum—a generic character of *Callopora.* The specimen figured by Nicholson in the Ohio Paleontology is 3.5 mm. in the diameter of the stem. Bassler states that the average diameter of the stems of *Sigillaroides* is 4 or 5 mm. Since there is really no distinction between *onealli* and the variety *sigillaroides,* except that of size, I have usually placed specimens with a diameter of less than 3 mm. under the species *onealli,* and specimens with a diameter of 3 mm. or over in the variety *sigillaroides.* It is stated by Bassler that the form *sigillaroides* possesses long, graceful branches without a tendency to anastomose as in *onealli.* My observation has been that the majority of species of *Callopora* will under certain circumstances anastomose. This is seen in *C. communis* to a marked degree, and is not uncommon in *C. dalei,* and *C. ramosa.* The true relation of *C. sigillaroides* and *C. onealli* seems to me to be that under favorable conditions of growth (nourishment, temperature, clearness of the water, etc.) the stems become larger (*sigillaroides*) and under unfavorable conditions they grow smaller (*onealli*). The variety *communis* is based on more substantial characters.

1.34Co, 2, 5, 6, 7, 8, 10, 11, 13....a similar form occurs near the base of the Waynesville formation, 1.34A3, 4.

CALLOPORA RAMOSA d'Orbigny.

Plate IX, figs. 5, 5a; Plate X, fig. 1; Plate XXVII, figs. 13, 13a.

Monticulipora ramosa d'Orbigny, 1850, Prodrome de Paleontologie, I, p. 25. (Not figured.)

"375, ramosa, d'Orb., 1848. *Cerioposa ramosa*, Readle (envoyé sous ce nom). Espèce rameuse dont les branches sont rondes. Etats-Unis, Cincinnati, Ohio (Blue Lime)."—d'Orbigny, *loc. cit.*

The original description of this species is wholly inadequate for its recognition. Edwards and Haime's very excellent figure has made its identification comparatively sure and this identification is now finally confirmed by the photographic reproduction of illustrations of the types in the collection of d'Orbigny, including a photograph of a thin section, in the Annales de Paléontologie, Tome 1, pl. ix (Paris, 1906).

Since the original description of this species is inadequate I quote here the excellent description given by Nicholson in the Monograph of the Genus Monticulipora (1881).

"*Spec. Char.*—Corallum dendroid, of cylindrical or elliptical branches which divide dichotomously, and vary from one to, generally, three or four lines in diameter. Surface covered with numerous conical or somewhat elongated 'monticules,' which are placed at intervals of from half a line to a line, and are not occupied by corallites of specially large or small dimensions. Calices sub-polygonal, with slightly thickened margins, about 1/90th inch in long diameter, surrounded by the openings of numerous small interstitial tubes. Corallites conspicuously divided into two series, the small ones being very numerous, and surrounding the larger tubes in a single row, sometimes completely isolating the latter, and being exceedingly variable in shape and size. In internal structure, both sets of corallites are traversed by complete horizontal tabulae, which are, however, much more numerous in the small tubes than in the large ones. Walls thickened towards their mouths, and apparently fused with one another.

"*Obs.*—The external characters of this species are so well known that they require no further remark here, its numerous conical monticules and the abundance of the interstitial corallites being sufficiently distinctive features. As regards internal structure, thin tangential sections exhibit in a striking manner the conspicuous division of the corallites into two sets of tubes, large and small, and the great development of the latter. The large tubes are very uniform in size, generally oval or circular in shape, and moderately thick-walled—the thickening of the wall, however, never proceeding to the extent that obtains in forms such as *M.* (*Heterotrypa*) *gracilis*, James, *M.* (*Heterotrypa*) *tumida*, Phill., and allied types. The small corallites are very variable in size and form, and are principally developed at the angle of junction of the large tubes; but they are commonly so numerous as to form a complete zone round the large corallites, though such a zone never consists of more than a single row. In tangential sections taken just below the surface, each of the large corallites is seen to be surrounded by a well-marked ring of sclerenchyma, all the tubes, however, being firmly united together. Between the bounding-rings of the larger corallites are situated the small tubes, which, in sections of this nature, are mostly oval or rounded. On the other hand, in tangential sections taken at a somewhat deeper level the marginal rings of the larger corallites are more completely separated from one another, and the small corallites are increased in size by the reduction of their bounding-walls, while their shape becomes more or less angular.

"Vertical sections show that the internal structure of the large and small tubes is conspicuously different, both sets of corallites being traversed by complete horizontal tabulae, which are greatly more numerous in the small tubes than in the large ones. The 'monticules' do not appear, as a rule, to differ in structure from the general mass of the corallum, but they seem sometimes to comprise a larger proportion of small tubes than is usually the case in the intervening parts of the skeleton. In the axial region of the corallum, as shown both in longitudinal and transverse sections, the corallites are thin-walled and polygonal, but they possess an abundance of tabulae. In the outer portion of their course, the corallites become thickened, their walls assuming a fibrous and laminated structure."—Nicholson, *loc. cit.*, pp. 110-113.

Callopora ramosa is a characteristic fossil of the middle and upper Lorraine formation throughout the Ohio and Indiana region and is at certain levels extremely abundant. In the lower part of its range it seems to present characters somewhat transitional to *C. dalei.* The above description and the figures reproduced herewith are amply sufficient for its identification.

1.33A3....1.34B1-3, 4-5, C14b, 1.12A2, 1.38P. Rather common at all of these localities.

CALLOPORA DALEI (Milne-Edwards and Haime).

Plate VIII, fig. 11; Plate XXVII, fig. 12.

Chaetetes dalii Milne-Edwards and Haime, 1851, Monographie des Polypiers Fossiles des Terrains Palaeozoiques, p. 266, pl. xix, figs. 6, 6a.

"Polypier dendroide, à rameaux cylindriques, larges de 6 a 8 millimètres; présentant à leur surface de petits mamelons coniques saillants, distants de 2 ou 3 fois leur diamètre. Calices à bords un peu épais, subégaux, subcirculaires, n'ayant qu'un tiers ou même un quart de millimètre.

"Silurien (inférieur) *Etats-Unis*: Ohio.

"Coll. de Verneuil."—d'Orbigny, *loc. cit.*

Edwards and Haime fortunately accompanied their meager description with very excellent figures, in consequence of which the identity of this species is in no doubt. Nicholson redescribed it in his monograph of the Genus Monticulipora as a variety of *C. ramosa*, and several years before this in the Quarterly Journal of the Geological Society of London and in the Ohio Paleontology as *Chaetetes approximatus*. In internal characters there is no particular difference between this form and *C. ramosa*. Externally it differs only in the small size of the monticules, and even in this particular it is an easy matter to find transitional forms between *C. dalei* and *C. ramosa*.

I have reproduced the figure of *C. approximatus* (= *C. dalei*) from the Ohio Paleontology, since it presents the usual appearance of the form under consideration. I believe that on the average, however, the monticules in typical specimens are rather smaller than shown in Nicholson's figure.

Callopora dalei occurs in the base of the Lorraine and extreme top of the Utica in immense numbers. In the lower part of its range it is associated with *Callopora communis* and in the upper part with *C. ramosa*. I have quite constantly used the stratum in which this species comes in in such numbers as the dividing line between the Utica and Lorraine. Associated with it is a small variety of *Platystrophia laticosta*, so that it seems really to mark the initiation of the *Platystrophia* zone. It is also at this point that the proportion of Limestone in the series begins to become predominant, and that others of the lithological and faunal characters of the Lorraine are initiated. It is also at about this level that the *Dalmanella multisecta* disappears.

5.9A41....1.34C13, 14a.

CALLOPORA RAMOSA var. RUGOSA (Milne-Edwards and Haime).

Plate X, fig. 2; Plate XXVII, figs. 14, 14a.

Chaetetes rugosus Milne-Edwards and Haime, 1851. Monographie des Polypiers Fosslies des Terrains Palaeozoiques, p. 268, pl. xx, figs. 6, 6a.

"Polypier rameux et très-semblable au *Chaetetes ramosus*, les calices ont à peu près la même largeur; mais il on diffère en ce que les monticules, qui sont très-allongés horizontalement, tendent à s'unir antre eux, de manière à simuler de gros bourrelets transversaux très-saillants. Ces bourrelets n'ont guère plus d'un millimètre d'épaisseur, et sont distants entre eux de 2 fois autant. Les calices sont tous presque égaux et larges d'un quart de millimètre.

"Silurien (inférieur). *Etats-Unis*: Cincinnati (Ohio).

"Coll. de Verneuil, où ce Polypier est indiqué sous le nom de *Ceriopora rugosa* (Dale Owen) qui probablement n'a pas été publié."—Milne-Edwards and Haime, *loc. cit.*

The relation of this form to *Callopora ramosa* is here pointed out by Edwards and Haime, and appealed so strongly to Nicholson that he placed the form as a variety of that species, a disposition with which the present author is inclined to agree. Connecting forms between the two certainly abound, and their range is much the same—*ramosa* appearing at a somewhat lower horizon and not extending its range quite as high as *rugosa*. Nicholson's description follows:

"*Obs.*—This form was originally defined as a distinct species by Milne-Edwards and Haime (Pol. Foss., p. 268, pl. xx, figs. 6, 6a), and is at first sight readily distinguished from typical examples of *M. ramosa,* D'Orb., by its external characters. In place, namely, of the conical monticules of the latter, the surface now exhibits numerous well-defined elevations, which are transversely elongated, so as to constitute so many discontinuous transverse ridges. These ridges vary in length; but they do not extend round the stems, and are usually sharp-edged, and are placed about half a line apart. In spite of this conspicuous difference, the more minute external and internal characters of *M. rugosa,* E. & H., are precisely similar to those of *M. ramosa,* D'Orb. Not only are the characters of the calices and interstitial tubes identical, but no difference of the smallest specific weight can be detected on a comparison of corresponding thin sections of the two forms. This will be rendered evident by a comparison of tangential and vertical sections of the type-form of *M. ramosa,* D'Orb., with similar sections of *M. rugosa,* E. & H. In the latter, as in the former, the corallum is composed conspicuously of two series of corallites, the large ones being oval or sub-polygonal, about 1/90th to 1/80th inch in diameter, and surrounded by numerous small tubes. The structure of the walls of the corallites is also the same, and both show exactly corresponding features in longitudinal sections. Upon the whole, therefore, there can be no hesitation in concluding that the mere external difference in the form of the monticules, being un-accompanied by any features of internal or structural difference, ought not to be allowed to count as of more than varietal value.'' —Nicholson, Genus Monticulipora, 1881, pp. 113-115, pl. ii, fig. 3, and figs. 19A and B, p. 114.

It is now well known that there is surprisingly little variation in the internal characters of the various species of the Genus *Callopora;* hence the grounds which here lead Nicholson to consider *C. rugosa* as a variety of *C. ramosa* would not have much force in the face of good external differential characters. It is precisely the latter, however, that are lacking; for while typical examples of the two forms look very unlike, nevertheless any large collection is sure to contain a considerable number of specimens that cannot consistently be referred to either one of the two forms, but fall in an intermediate position. It is this fact that leads me to reduce the form *rugosa* once more to varietal rank.

1.33A3....1.34C, 14b, B1-3, 4-5....1.12A2....1.38A65, Ba-h. A form with the same external characters occurs in the Elkhorn division on Elkhorn Creek, near Richmond, Indiana, 1.41A10a.

CALLOPORA SUBPLANA Ulrich.

Plate X, figs. 4, 4a; Plate XXVII, fig. 15.

Callopora subplana Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 253, pl. xi, figs. 7-7b.

''Zoarium ramose, the branches cylindrical, from .2 inch to .5 inch in diameter, and dividing dichotomously at intervals varying from .6 inch to one inch. Cells polygonal in unworn examples, subpolygonal or rounded in worn specimens. The surface exhibits clusters of from four to eight cells, that occasionally are slightly elevated above the general surface, and are conspicuously larger than the ordinary cells which surround them. The latter vary in diameter from 1/70th to 1/60th of an inch (i. e., six to seven cells may be counted in the space of .1 inch), while those composing the clusters may attain a diameter of 1/40th of an inch, though their usual diameter is only about 1/50th inch. The interstitial cells are comparatively few, being most numerous and noticeable between the large cells of the clusters mentioned. Over the other portions of the surface they usually occur at the angles of junction of the ordinary large tubes. They are, however, always inconspicuous, and easily overlooked.

''In longitudinal sections the tubes in the axial region of the zoarium, have very thin, flexuous, and often crimped walls. Diaphragms are usually not developed here, excepting a few (six to nine) in the young tubes just above the point of their origin. These are placed at distances apart equaling about two of their diameters at the point of crossing. As the tubes bend outward to reach the surface their walls are thickened, the interstitial tubes make their appearance, and numerous diaphragms are developed in the large tubes, the latter often inosculate, while the distance between them usually varies from one-fourth to one-half of the diameter of the tube crossed. The diaphragms in the interstitial tubes are always complete and equally crowded in all.

"Tangential sections show that the tubes just below the surface have much thickened walls, their visceral chambers being rounded or oval. The walls of adjoining tubes are seemingly fused together, so that the original boundary line cannot be detected. The cavity of each tube is surrounded by a secondary deposit of dark, concentrically laminated sclerenchyma, while the original wall is represented by apparently structureless (in this section) sclerenchyma, of much lighter shade. The interstitial cells are variable in size and shape, and comparatively much reduced in number, being, as a rule, less numerous than the proper tubes.

"The characters which distinguish *C. subplana* from all other species of the genus known to me from the Cincinnati Group, are found in its robust growth, the large size of the cells, the conspicuous clusters, and the proportional paucity of the interstitial tubes."—Ulrich, *loc. cit.*

1.34C2, 5, 9....1.38Ba.

CALLOPORA SUBNODOSA Ulrich.

Plate X, figs. 5, 5a.

Callopora subnodosa Ulrich, 1890, Geol. Illinois, VIII, p. 417, pl. xxxiii, figs. 5-5c.

"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. Zooecial walls comparatively thin throughout. Zooecia 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 zooecial tube. The mesopores are tabulated very closely throughout; about three diaphragms in a space equaling 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."—Ulrich, *loc. cit.*

This is the only species of *Callopora* so far reported from the Richmond series. That there are several other species in these rocks is certain, although I have not specimens in sufficient number at present to warrant the establishment of the new species. Two of these forms I have figured, and another from the lower part of the Waynesville has the superficial appearance of *C. sigillaroides.* Speaking more particularly of the specimens with the general appearance of *C. subnodosa,* I find some variation in the extent of the tabulation of the zooecia, which is not always as simple as indicated by Ulrich. In many of the specimens that do not seem to me to be specifically separable from *C. subnodosa,* the zooecia are tabulated throughout their length. Other specimens commonly associated with the typical form have instead of the low-rounded monticules, quite sharp monticules, similar to those of *C. ramosa,* and others still are entirely devoid of any monticules at all, and yet have the internal and other characters of *C. subnodosa.* As to whether we are dealing here with the variants of a single species or with several distinct species I am not yet in a position to say, but I suspect that the former is the case.

C. subnodosa (and its varieties) is a common fossil in the Richmond series.

1.34A10, 14a, 14b, 15, 16, 17, 18, 19, 20, 21, 22, B4-5....1.41A4, 5, 6, 7, 8, 9, B1, 2, 3, C1, 2-3, D1, 2, 3, E1, 2, 3, 4, 6....1.12E3, F3.

CALOPORELLA CIRCULARIS (James).

Plate X, figs. 6-6c.

Monticulipora (*Heterotrypa*) *circularis* James, 1882, The Paleontologist, No. 6, p. 46. (Not figured.)

"Corallum, concavo convex; the concavity of the base corresponding with the convex upper surface, causing an even thickness of from less than half a line to about one line in different specimens; size, varying from one-fourth of an inch to one inch in diameter; circular in outline; surface, even and destitute of 'monticules,' or groups of larger calices than the average; apertures of cells of unworn specimens, sharp, but they are seldom found in that condition, nearly all, as far as observed, being more or less abraded, showing the cell walls as much thickened; calices, subcircular, or somewhat angular in some cases, uniform in size, seven or eight in the space of one line, sometimes arranged in regular, slightly curved rows of from four to twelve or more; no minute tube apertures observed. The concave base of unworn examples is covered with a very thin, delicate epitheca, showing very fine concentric lines, and radiating striae, worn ones show the bases of the corallites. Specimens partly embedded in the surface of rocks are as often found base upward as downward; detached specimens are not uncommon, all indicating the free habit of the species.

"Sections of the *interior* show two series of tubes, a larger and a smaller, the larger, only, being noticeable at the *surface.* In *tangential* sections the larger tubes are mostly circular with distinct borders; the smaller, which surround the others in some cases, are the most numerous, and vary greatly in shape. In a tranverse section, taken just *above the base,* the larger tubes seem to be slightly expanded, and the smaller not occupying so much space, otherwise it is very much like the *tangential* section. In *vertical* section the tubes take a somewhat bent or tortuous course, and are tabulate from the base to the upper surface, the smaller ones generally more closely than the larger. In most cases, the tabulae are horizontal, but in some they take an oblique or bent course across the corallites.

"Some specimens found associated with this exhibit a *slight* tendency to forming 'monticules,' but in other respects they seem identical.

"In outline and habit of growth this resembles M. sp. *discoidea,* James, but in other respects it is materially different, particularly the *interior* structure."—James, *loc. cit.*

The internal characters of this species (the *C. harrisi* of Ulrich) are substantially the same as in *Callopora,* and it is not improbable that it may prove to represent the young of some species of that genus.

1.33A3.

CERAMOPORELLA DISTINCTA Ulrich.

Plate X, fig. 7; Plate XI, figs. 2, 2a.

Ceramoporella distincta Ulrich, 1890, Geol. Illinois, VIII, p. 464, pl. xxxix, figs. 6, 6a.

"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. Zooecia 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 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 zooecia, occasionally completely isolating a zooecium. In the fully matured perfect condition their apertures are closed by a thin membrane.

"This very pretty species is distinguished by its small cells and rather widely separated zooecia apertures. Their oval form and the continuation of the peristome around the anterior margin are also quite distinctive."—Ulrich, *loc. cit.*

Not uncommon in the Utica formation.

1.34C2, 5.

CERAMOPORELLA GRANULOSA Ulrich.

Plate XI, figs. 3-3a.

Ceramoporella granulosa Ulrich, 1890, Geol. Illinois, VIII, p. 466, pl. xli, figs. 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. Zooecia 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 zooecia. 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 arrangements of its parts, distinguish this species from *C. distincta,* which it resembles in the size of the zooecia. I am not acquainted with any other species that would admit of closer comparisons." —Ulrich, *loc. cit.*

This form or a variety occurs in the Arnheim, near Harman's Station, Indiana.

CERAMOPORELLA OHIOENSIS (Nicholson).

Plate XI, figs. 4-4g.

Ceramopora ohioensis Nicholson, 1875, Pal. Ohio, II, p. 265, pl. xxv, figs. 10-10e.

"Polyzoary incrusting, forming thin expansions attached to the surface of Brachiopods or Corals, and consisting, typically at any rate, of a single layer of oblique cells. Cells arranged in intersecting diagonal lines, and disposed in a somewhat concentric manner round more or fewer central points; their upper walls thin and arched; the cell-mouths oblique, and, when most perfect, semicircular in shape. About eight cells in the space of one line.

"Such are the appearances presented by this fossil when quite perfect, and its examination in this condition leaves no doubt as to the propriety of placing it in Hall's genus *Ceramopora.* Worn examples, however, exhibit very different characters, and when the entire original surface has been abraded it is sometimes difficult or impossible to determine whether one is dealing with this or some entirely different form.

"When slightly worn, the appearances shown in fig. 10*b* [of Nicholson's paper] are exhibited. The delicate front wall of the cell has now disappeared, and the cavity of the cell appears to be divided into two distinct compartments, a larger and a smaller, both of a somewhat triangular shape, by an oblique internal septum. Other smaller cavities appear in addition in the walls separating the different cells.

"When more deeply worn down, or under certain conditions not clearly understood, the cells appear in the form of rounded or oval apertures, arranged in diagonal rows, but separated by a vast number of small rounded foramina, which appear to be the mouths of interstitial tubuli. In this condition the fossil presents much the appearance of certain species of *Chaetetes* (*Monticulipora*).

"The best examples of this singular polyzoon that I have seen grow in the form of thin crusts, rarerly exceeding one-fourth of a line in thickness, upon *Strophomena alternata* and upon various species of *Chaetetes.* In some examples, it would seem that several layers of cells are superimposed on one another; but I do not feel satisfied as to the real nature of these specimens. Not uncommonly the cells are concentrically disposed round a number of irregular areolae, each of which is formed by a number of cells radiating from a central point. Young examples form circular crusts, with a slightly cupped center, from which the cells radiate in every direction. Lastly, examples are not uncommon which appear to have the form of small branching stems. Some of these, certainly, are merely constituted of thin crusts growing upon various ramose species of *Chaetetes.* Others, however, appear to be entirely composed of the polyzoon itself, without the intervention of any foreign body; and it is possible that these will eventually prove to be a distinct species."—Nicholson, *loc. cit.*

The internal characters of this species present little complexity and are sufficiently well indicated by the figures. *C. ohioensis* is a common fossil ranging throughout the Cincinnati group.

1.33A3....1.34C5, 7, 11, 13, 14a, 14b, B1-3, A1, 3, 7, 8, 9, 15b, ...1.41A4, 5, 6, 7, 8, D1, 2, E1, 2, 3, 4, 6....1.12A2, E3, F3.

CERAMOPORELLA WHITEI (James).

Ceramopora whitei James, 1878, The Paleontologist, No. 2, p. 12, (Not figured.)

"Polyzoary a thin crust grown upon foreign substances,—generally corals—sometimes spread all around, and in and over the inequalities of very irregular surfaces of bodies of considerable size —3x6 inches, less or more. The cells seem to be mostly direct, but in some places may be slightly oblique and very little elevated at the apertures. An average of about 10 cells in the space of a line measuring in any direction, very irregular in shape and size—circular, oval, triangular and other forms. Distributed irregularly over the surface are slightly elevated areolae, where the cells are generally smaller than the average on other parts. Cell walls very thin. A *few* minute tubules between some of the larger cells.

"This species differs from Professor Nicholson's typical form of *C. Ohioensis* in most of its features materially. The cell apertures are disposed in a confused manner (seemingly) over the surface of various shapes and sizes, and but slightly oblique or elevated, if at all, and somewhat smaller. That species is generally found grown upon shells, this *rarely*.

"*C. Ohioensis* is described as having the cells arranged in intersecting diagonal lines, and disposed in a somewhat concentric manner round more or fewer central points; their upper walls thin and arched; the cell-mouths oblique, and when most perfect, semi-circular in shape. About 8 cells in the space of one line. Our species is quite different from this description, the cells *not* being arranged in intersecting diagonal lines in a somewhat concentric manner round fewer or more central points."—James, *loc. cit.*

This species is redescribed by Bassler as follows (James Types, p. 29):

"The zoarium forms thin crusts over foreign bodies, but by the superposition of numerous layers may become massive. Each zoarial layer is short, rarely exceeding 1.5 mm. in thickness. Surface smooth, the maculae or clusters of rather thick-walled mesopores not being elevated. Zooecia small, more or less angular, thin-walled and direct, about 7 in 2 mm. Mesopores generally few, sometimes absent altogether. Lunarium occupying from one-fourth to one-third of the zooecial circumference, seldom over-arching the zooecial cavity and always a more or less inconspicuous feature of the surface. The internal structure is essentially the same as in other species of the genus and is more clearly brought out by the figures," etc.

Not reported from Indiana, so far as I am aware. It may be expected to occur in the upper Lorraine and Richmond formations.

CHILOPORELLA FLABELLATA Ulrich.

Plate XI, figs. 1, 1a, Plate XII, figs. 1-1b.

Fistulipora flabellata Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 28, pl. vii, figs. 26-26b.

"Polyzoary forming irregular, fan-like expansions, carrying cell mouths on both sides. Thickness usually varying from one to two lines. Surface sometimes raised into broad and inconspicuous monticules, carrying tubules of the ordinary size. Cells oval, with apertures a little arched, arranged in bent and rather irregular rows; about five cells occupying the space of one line, the distance between them being equal to a little more than their diameter.

"Intertubular space occupied by a great number of minute cells, which are nearly equally distributed between all the tubes of larger or ordinary size.

"Longitudinal sections show the tubules to be nearly vertical in the middle of the polyzoary, and then gradually bending outwards to the surface. Tabulae are very sparingly developed. These sections clearly demonstrate that the interstitial tubuli observed on the surface, are not of the nature of a coenenchyma, but are only aborted cells. They are developed only near the surface. In the central portions of a transverse section, the tubes are angular, of unequal size and irregular form, with no minute tubuli between them."—Ulrich, *loc. cit.*

1.34B4-5.

COELOCLEMA ALTERNATUM (James).

Plate XII, figs. 2-2d; Plate XXVII, fig. 16.

Ceramopora alternata James, 1878, The Paleontologist, No. 1, p. 5.

"Polyzoary consisting of hollow, branching, cylindrical or compressed stems from one to four lines in diameter, with irregular swellings; the hollows filled with foreign matter, (clay). Cell apertures of the most perfect specimens, elevated, oblique, arched, subcircular or oval; five or six in the space of a line including the interspaces; generally arranged in alternating rows, sometimes in a diagonal manner around the branches. Spaces between the cells equal to their diameter, or a little more or less on different examples. Slightly cut longitudinal sections of some specimens show the cells arranged in diagonal, alternating rows of a lozenge-shape, with minute interstitial pores. Distributed over the surface about two lines apart, are spots, sometimes slightly elevated, bearing fewer cell apertures and more or less of the small pores. The surface of worn or weathered examples—mostly so found—are nearly smooth; destitute in most cases of prominent cell mouths, but show more minute interstitial tubes and divisions, than perfect specimens."—James, *loc. cit.*

James's description together with the figures given herewith is adequate for the identification of this species, which is a very common fossil in the middle and upper part of the Eden formation.

5.9A31....1.34Co, 5, 6, 7, 8, 10, 11....1.38A5, 11, 13.

COELOCLEMA COMMUNE (Ulrich).

Plate XII, figs. 3-3c; Plate XXVII, fig. 17.

Diamesopora communis Ulrich, 1890, Geol. Illinois, VIII, p. 469, pl. xxxix, fig. 3a; and pl. xli, figs. 5-5b.

"This species is closely related to the preceding [*D. vaupeli*—*C. alternatum*], but differs in being more robust in growth, in having well marked maculae, with subsolid centers, from which the cell apertures radiate out in all directions. The apertures immediately surrounding the maculae 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."—Ulrich, *loc. cit.*

Bassler* has shown in a recent paper that the *Ceramopora concentrica* James, is a synonym of *Ceramoporella ohioensis;* and hence that *Coeloclema concentrica* (James) is a synonym of *C. commune* (Ulrich) instead of the reverse being the case.

Coeloclema commune is abundant in the Eden, and in the upper Eden it is associated with *C. alternatum,* from which it may be distinguished by the absence of maculae in the latter species.

5.9A31....1.34C5, 7, 8, 9....1.38A21, 24, 37.

CONSTELLARIA CONSTELLATA Dana. (Van Cleve MS.)

Plate XII, figs. 4-4e; Plate XXVII, fig. 19.

Constellaria constellata Dana, Zoophytes of the Wilkes Expedition, 1846, p. 537.

"GENUS CONSTELLARIA. We separate under this name a species with the compressed branches, internal structure, and surface cells of many of the above genus [*Stenopora*], but having the verrucae oblong and arranged in stellate groups over the surface, a character of physiological importance. Glomerate forms may also occur. A species of this genus is named *Ceriopora constellata* on the plates of Western fossils by Van Cleve. The genera Pelagia and Lichenopora, described in the appendix to the Madreporacea, have a similar stellate arrangement, but they are of doubtful character, and the last has been referred to the Bryozoa group.

*Bassler, Proc. U. S. National Museum, vol. XXX, pp. 25, 26.

A recent species described by Michelin, *Lichenopora glomerata,* is quite similar to the Constellaria in its surface and the size of the cells; but there are no characters stated which decide that it belongs with the Favositidae."—Dana, *loc. cit.*

The internal characters of this species were very carefully described by Ulrich (Cincinnati Society, 1883, p. 267), under the name *Constellaria florida,* proposed by him for a supposedly new species in 1882. From his description I condense the following:

Tangential sections cutting just beneath the surface of the zoarium present two phases. The usual appearance is as follows: The maculae which at the surface appear to be subsolid are seen in the section to be composed of numerous very thin walled, often elongated, angular interstitial cells, which in the center of the macula are larger than the true zooecia, while in the extremities of the rays they are not more than half as large. Between these rays five to fifteen of the zooecia are aggregated into irregularly elliptical groups. The zooecia in these groups are subelliptical in shape. In the intermonticular spaces the zooecia are circular in shape and thicker walled. They are sometimes completely isolated by a series of large mesopores, though more usually they are in partial contact. Sections cut from a sufficiently matured example show the second phase as follows: In this phase the walls of the zooecia are comparatively thick and the mesopores are scarcely at all visible. In their place is a mass of sclerenchyma interspersed with small dark spots, each enclosing a smaller lucid spot. These latter are probably small foramina.

Longitudinal sections show that the axial region is occupied by rather large and very thin walled zooecia in which diaphragms are nearly lacking. As they approach the surface the zooecia bend outward abruptly, and in the mature region a very large number of rapidly expanding mesopores are developed, in which diaphragms occur, becoming crowded as the surface is reached. These diaphragms are as a rule complete and at about the same level in adjoining tubes. A common fossil in the lower part of the Lorraine.

1.34C13, 14a....1.38P.

CONSTELLARIA CONSTELLATA var. PROMINENS Ulrich.

Plate XXVII, fig. 18.

Constellaria florida var. *prominens* Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 269, pl. xiv, fig. 3.

"Figures 3 and 4 represent two varieties, which are sufficiently marked by their external characters to render their separation from the more typical forms of the species usually an easy task. I therefore propose the name of *prominens* for fig. 3. It is distinguished by its large and remarkably prominent monticules, which, so far as observed, never coalesce. Their diameter will average about .15 of an inch; their height about .05 inch; in the space of one half inch square, about sixteen may be counted. The branches are usually sub-cylindrical, with an average diameter of about .4 of an inch.

"This variety is apparently restricted to a few feet of strata, and marks an horizon about 200 feet above low water mark."—Ulrich, *loc. cit.*

This species seems to mark the boundary between the Eden and Lorraine formations.

1.34C13....1.38A65.

CONSTELLARIA LIMITARIS Ulrich.

Plate XIII, fig. 2; plate XXVIII, fig. 2.

Stellipora limitaris Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 126, pl. xii, figs. 8-8c.

"Grows in cylindrical or sub-cylindrical, sometimes hollow branches, the diameter of which varies from three to five lines; or in small lobate or sub-palmate masses. Branches in the ramose examples dividing dichotomously at varying distances, irregularly thickened and nodulated. Surface with the tube-mouths on all sides, the tubes cylindrical and radiating in all directions from an imaginary central axis. Scattered, generally over the entire surface, are numerous stellate spaces, each of which has a diameter of a line or a little more, sometimes considerably depressed, but usually on a level with the surrounding surface; the number of the rays radiating from the body of the star varies from five to eight; these frequently bifurcate once or twice, and unite with those emanating from the adjacent stars, thus producing a sort of network. The stars are usually regular in outline, sometimes elongated, and arranged in rather irregular transverse or oblique rows, three stars generally occupying a space of three and a half lines; it is however not very rare to find specimens with a portion of the surface destitute of the stellate spaces. The central area and the rays of the stars are composed of aggregations of very minute subangular tubuli, but appear to be solid, unless examined with a sufficiently high magnifying power. The surface between the stellate maculae is covered with small circular calices, the margins of which, in protected parts, are slightly raised; from six to eight tube orifices occupy the space of one line. Intertubular space about one third as thick as the width of the tube mouths, and minutely tubular.

"Longitudinal sections of the branches present the tubes as proceeding in a gentle curve from the middle or axis of the branch to the surface, and as they approach the surface and have arrived to within one line of the same, they bud off one or two more slender tubes; the tubes before they have been thus multiplied are traversed by complete and close tabulae, a little more than one tube diameter apart. Near the surface the tubes are of two kinds, smaller and larger ones; the former are at intervals collected into groups, which represent the stellate maculae on the surface; between these the remaining tubes are placed alternately, one larger and one or two smaller; the large tubes representing the true cells, while the smaller ones represent the minute tubuli in the intercellular spaces. The diaphragms in both kinds of tubes are close set, about two thirds of a tube diameter distant from each other.

"In transverse sections the tubes near the margin are seen to be cut longitudinally, while in the center they are divided transversely, and here they are thin-walled and generally with an hexagonal outline.

"In sections taken parallel with and close to the surface, the stellate spaces are seen to be occupied by a network of sub-angular cells. The tubules are circular, and fill up the space not occupied by the maculae; they are separated by a similar network of minute cells as those composing the maculae.

"This species in its external characters approximates closely to *Fistulipora,* McCoy, since the stellate and intertubular spaces in their structure are essentially the same as the cellulose tissue, of which the intertubular spaces and maculae, in most of the species of that genus, are composed. *Fistulipora* (*Callopora*) *incrassata,* Nicholson, has star-like spaces, occupied by very minute tubuli, but these spaces have no radiating ridges surrounding them. In *S. limitaris* there are also none of these ridges, and in these two species the resemblance is very manifest. On the other hand, in sections of *S. limitaris,* taken parallel with and close to the surface, we find a striking similarity to sections of the same kind of *Chaetetes decipiens,* Rominger, and *C. frondosus* D'Orbigny, while in longitudinal sections much affinity is presented to several ramose species of *Chaetetes.* The species of *Stellipora* and their numerous varieties, in fact are connecting links between *Chaetetes* and *Fistulipora. Stellipora anthelloidea,* Hall, is distinguished from this species, exteriorly, by its sub-frondescent growth, by having the spaces between the rays of the stellate maculae raised, and the tubes smaller. Interiorly we find that the tubes in the middle of the branch or frond are crossed by remote tabulae, and as they approach the surface the curve is more abrupt than is the case in *S. limitaris.*"—Ulrich, *loc. cit.*

This beautiful species is found associated with *C. polystomella* in the Richmond formation. It is readily distinguished from that species by the fact that the rays of the maculae are not elevated, but rather depressed, and also by the fact that *C. limitaris* is a ramose or sub-ramose species, while *C. polystomella* is frondescent. *C. fischeri* which somewhat resembles it in the appearance of the surface is not an associated species, and besides is also frondescent.

1.34A13b, 14a, 14b....1.41D1.

CONSTELLARIA POLYSTOMELLA Nicholson.

Plate XIII, figs. 1-1b; Plate XVIII, fig. 1.

Constellaria polystomella Nicholson, 1875, Pal. Ohio, II, p. 215, pl. xxii, figs. 7, 7a.

"Corallum in all essential points of structure resembles the preceding [*Constellaria antheloidea*], consisting of erect, flattened, palmate expansions, the thickness of which is from two to three lines. Surface covered with very prominent stars, formed of a series of elevated ridges radiating from a central depressed area, and surrounded by depressed interspaces. Each star is usually composed of from eight to as many as thirteen elevated ridges, some of which are smaller than the others. The ridge-like elevated rays are occupied by comparatively large sized circular calices, which are also present, though not so closely set, in the interspaces between the stars. The central areas of the stars are occupied by innumerable excessively minute circular pores, which appear to be the openings of coenenchymal tubuli, and similar pores exist everywhere between the corallites which are placed in the intervals between the different stars. Each star is (in the best preservd portions of the coral) circumscribed and separated from the adjacent stars by a distinct hexagonal border, which has no great width, and is occupied solely by the coenenchymal tubuli, and not by the ordinary corallites.

"Though undobtedly closely allied to *Constellaria antheloidea*, Hall [=*Constellaria constellata* Dana], it seems to me that *C. polystomella* is sufficiently distinguished by the fact that the different stars are definitely bounded in the latter and appear to occupy definite polygonal areas, whilst in the former no line of demarkation can be detected between the different stars other than that afforded by the outer terminations of the elevated ridges. In addition to this character, however, the present species would seem to be distinguished by its very prominent stars, by the large number of rays which are generally present in each individual star, and by the conspicuous presence, both in the central areas of the stars and also in the interspaces between the different corallites elsewhere, of very numerous and very minute cylindrical tubuli, which can hardly be regarded as other than coenenchymal."—Nicholson, *loc. cit.*

This species is sufficiently distinct from *C. constellata,* and occupies a quite different position in the section from that species. *C. polystomella* is confined to the Richmond formation and *C. constellata* to the Lorraine. The figures of tangential and longitudinal sections given herewith will indicate the internal characters better than pages of description.

1.34A12, 14a, 14b....1.41D1, E3....1.12F3.

DEKAYIA APPRESSA Ulrich.

Plate XIII, fig. 3.

Dekayia appressa Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 152, pl. vi, figs. 7-7b.

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

Cells thin-walled, with the exception of the groups mentioned, in all probability consist of one kind only, those of the ordinary size having a diameter of 1/130th inch, while that of those in the clusters may exceed 1/90th inch. An occasional small cell is met with, that, though I much doubt it, may be of the nature of an interstitial cell.

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

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

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

1.34B1-2.

DEKAYIA ASPERA Milne-Edwards and Haime.

Plate XIII, figs. 5-5b; Plate XXVII, fig. 20.

Dekayia aspera Milne-Edwards and Haime, 1851, Monographie des Polypiers Fossiles des Terrains Palaeozoiques, p. 278, pl. xvi, figs. 2, 2a.

"Polypier en masse subramifiée et un peu irrégulière. Calices petits, polygonaux, à murailles simples, peu inégaux, présentant à leur angles et à des distances variables des cônes très-saillants, compactes, aigus et striés. qui donnent un aspect spinuleux à la surface. Largeur des calices, un quart de millimètre. Planchers horizontaux.

"SILURIEN (inférieur). Etats-Unis: Cincinnati (Ohio).

"Coll. de Verneuil."—Milne-Edwards and Haime, *loc. cit.*

Owing to the unusually characteristic surface features of this well known species, the rather meager description of Edwards and Haime is sufficient for its recognition, and coupled with his figure leaves no doubt as to the identity of the form. The internal characters, however, are equally interesting and characteristic, and I therefore take the liberty of appending a further description of this important species.

Zoarium consisting of somewhat flattened stems attaining a diameter of several cm. Surface smooth except for the unusually conspicuous spines caused by the projection at the surface of the large set of acanthopores. This gives an unmistakable appearance to the species. The zooecia are polygonal and thin walled, and mesopores are practically absent. No monticules or maculae of any kind.

In tangential sections the zooecia are thin walled, polygonal, and in complete contact at all points. An occasional smaller zooecium, probably a young individual, is seen. The most striking feature of such sections is the enormous acanthopores, at times nearly as big as an ordinary zooecium. Interspersed among these large acanthopores, and plainly visible, *even in the mature region,* are a number of smaller acanthopores of about the size normal to *D. frondosa.* The wall structure is much the same, also, as in the latter species.

In longitudinal sections the zooecia are seen to bend very gradually outward from the immature region and to reach the surface at nearly a right angle. No diaphragms or other structures are present, except rarely a diaphragm or two near the surface. The large acanthopores are shown by longitudinal sections to extend into the immature region, and sometimes to cross over from one zooecium to another. They are in fact a very conspicuous feature of such sections. This is the only feature that causes longitudinal sections of this species to differ from similar sections of *D. magna.*

1.34C13, 14a....1.38P.

DEKAYIA FRONDOSA (d'Orbigny).

Plate XV, figs. 1-1e; Plate XXVIII, fig. 9; Plate XXIX, fig. 1.

Monticulipora frondosa d'Orbigny, 1850, Prodrome de Paléontologie, I, p. 25. (Not figured.)

"*376. Frondosa, d'Orb., 1848. Espèce à larges frondes dont les monticules sont coniques et très-espacés. *Etats-Unis,* Cincinnati, Ohio."—d'Orbigny, *loc. cit.*

The status of *Monticulipora frondosa* d'Orb. has finally been determined by the publication of sections of the type specimen in the collection of d'Orbigny. It proves to be the form identified as such by Ulrich in 1882* and referred to the genus *Heterotrypa.* The first publication of figures of thin sections of the type of this species is in a recent paper by Ulrich and Bassler,† and a reproduction of a photograph of a section has been published still more recently in the Annales de Paleontologie, Tome I, pl. ix, fig. 10, together with a figure of the type (pl. ix, fig. 9). The writer's *Dekayia perfrondosa* therefore becomes a synonym of *D. frondosa.*

The following description of the species is based on specimens in the writer's collection:

The zoarium is in general frondescent, though massive or submassive forms occur, especially in the upper part of its range. The large example figured by Milne-Edwards and Haime is a good example of the frondescent form, and I have figured in this report an example of the massive form. I suspect that as a matter of fact the massive forms are the basal portions of the species, and that in all cases when fully grown, it developed fronds. O'Orbigny's specimen is a small, somewhat irregular frond, with the typical surface characters. Superficially the fronds are set with rather small, usually sharp, monticules, although in such examples as figured by Edwards and Haime, the monticules are rather low and rounded, if he has correctly indicated them. I must say that monticules of this sort are the exception. In the type, the monticules are spaced about 3 mm. from center to center, as measured on the photograph given in the Annales de Paleontologic. The zooecia vary from polygonal to circular in shape, the latter form occurring where the mesopores are more abundant. The latter are not aggregated in the monticules, notably, but are distributed rather uniformly throughout the zoarium.

In tangential sections cutting the mature region the zooecia are moderately thick walled and circular, touching each other at

*Jour. Cin. Soc. Nat. Hist., V, p. 133 and p. 235.

†Smithsonian Miscellaneous Collections, vol. 47, p. 25, pl. xi, figs. 1-3.

several points, except in the case where the mesopores are numerous, when they are completely isolated by the latter. The lumen of the zooecium is surrounded first by a zone of light-colored sclerenchyma, and this in turn by a narrow zone of dark-colored sclerenchyma, the remaining space between neighboring zooecia consisting of light-colored material, in which the mesopores are lodged. The walls of the latter are rather indefinite. The wall structure, just described, characterizes in a general way all species of the genus.

Longitudinal sections show that the zooecial walls are very thin in the axial region, and become thickened immediately upon passing into the deep mature region. In the latter, diaphragms are abundant, in some specimens, and only moderately abundant in others. In the section of the type, as figured in the Annales de Paleontologie, they are abundant. In the mesopores, diaphragms are about twice as abundant as in the zooecia. An occasional curved diaphragm is present.

Acanthopores are present in moderate number, and are usually of small size, though in some specimens an occasional acanthopore of large size can be demonstrated. This species is found throughout the greater part of the Lorraine, and at some horizons is common.

1.33A3....1.34B1-3, 4-5, C13, 14a, 14b....1.12A2....1.38Ba-h.

DEKAYIA FRONDOSA var. CYSTATA Cumings.

Plate XIV, figs. 1, 1a; Plate XXVIII, fig. 3.

Dekayella cystata Cumings, 1901, American Geologist, XXVIII, p. 375, pl. xxxv, figs. 1-6a.

"Zoarium consisting of flattened branches, at times 30 mm. or more in width. Surface covered with small conical monticules, about three in the space of 5 or 6 mm. Cells 0.2 mm. to 0.15 mm. in diameter. The monticules are composed of groups of cells larger than the average, interspersed with a greater or less number of very minute cells (mesopores). The latter are practically confined to the regions of the monticules.

"Tangential sections reveal the characteristic cell structures of the genus, with the large and small sets of acanthopores.

"Longitudinal sections show numerous diaphragms about one-half cell diameter apart in the large cells and much more numerous in the mesopores. A peculiarly characteristic thing is the presence of an occasional cystiphragm, especially near the surface.

"Observation: This species might easily be mistaken for *Heterotrypa subpulchella,* from which it differs in the two sets of acanthopores and the presence of curved diaphragms."—Cumings, *loc. cit.*

1.34B4-5, C14b....1.38P. 1.33A3.

DEKAYIA INFLECTA (Ulrich).

Plate XV, figs. 2-2a.

Heterotrypa inflecta Ulrich, 1890, Geol. Illinois, VIII, p. 414, pl. xxxvii, figs. 2-2d.

"Zoarium frondescent, seldom over four cm. in width, six cm. in height, and five mm. thick; usually only about three in thickness. Surface smooth or with slight elevations of cell apertures somewhat larger than the average. Zooecial tubes bending abruptly into the cortical region, with walls slightly flexuous in the axial region. Zooecia 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 zooecia, rather more numerous in the clusters. Diaphragms only one or two in each zooecial 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.*"—Ulrich, *loc. cit.*

This is another of the species of *Dekayia* with numerous and strong acanthopores, as in the *D. ulrichi* group. In the specimen figured herewith, the acanthopores are distinctly of two sizes. It is altogether a more delicate species than *D. frondosa* in its zoarial habits and is distinguished superficially by the fact that the acanthopores strongly inflect the zooecia, from which fact the name is derived. It is not a common form.

1.33A3.

DEKAYIA ULRICHI var. LOBATA Cumings.

Plate XXVII, fig. 21.

Dekayella ulrichi var. *lobata* Cumings, 1902, American Geologist, XXIX, p. 203, pl. ix, fig. 2; pl. x, fig. 5; pl. xi, figs. 3, 4.

"Zoarium consisting of irregularly lobed and greatly compressed branches or of wavy true fronds arising from a cylindrical base which is doubtless attached by an expansion as in other frondescent species. An average frond has a thickness of 4 mm. to 5 mm. and a breadth of 20 mm. or more. Surface nearly smooth, often completely so; but showing in some specimens subsolid sometimes slightly elevated maculae of cells somewhat smaller than the average. Zooecia round, about 45 to the centimeter and from 0.16 mm. to 0.2 mm. in diameter. Mesopores numerous, angular, filling all the interstices between the zooecia. The surface of some specimens seems to be covered in places with a thin pellicle, as in other species of *Dekayia*.

"Longitudinal sections show that the diaphragms are approximately horizontal, fairly crowded in the mature region and considerably more numerous in the mesopores, which are constricted at the level of each diaphragm. The walls present the peculiar beaded appearance characteristic of *D. ulrichi*.

"Tangential sections near the surface show that the zooecia are ring-like in the mature region, with fairly thick walls. The acanthopores are fairly abundant, and of two sizes, the smaller somewhat more numerous. The ratio of the diameters of the largest and smallest acanthopores seen, is about as four to one." —Cumings, *loc. cit.*

This species is not uncommon in the lower portion of the Lorraine near Manchester Station, Indiana.

1.34C14a.

DEKAYIA MAGNA Cumings.

Plate XIII, figs. 6, 6a; Plate XXVIII, fig. 8.

Dekayia magna Cumings, 1901, American Geologist, XXVIII, p. 375, pl. xxxiv, figs. 1-6.

"In form and general appearance this closely resembles *D. aspera* E. & H. The zoarium consists of irregular flattened branches (as in the Lawrenceburg specimen) or more frequently of robust frequently branching masses (as in the Vevay specimen) of a diameter of 40 mm. or more. Spines can occasionally be detected upon the surface.

"Tangential sections show that the cell walls are thin with usually a well defined median lamina. Acanthopores few, *small.* Diaphragms extremely few; occasionally one or two near the surface.

"Observation: This form might be considered as identical with *D. aspera* but for the small size and less frequency of the acanthopores.

"*Locality*: Vevay and Lawrenceburg, Indiana, in the *Platystrophia laticosta* zone."—Cumings, *loc. cit.*

After the above description was published, I about came to the conclusion that I had been dealing with an abnormal example of *Dekayia aspera.* I am still, however, unable to demonstrate the large acanthopores which characterize the latter species, and it therefore seems to me to be best to retain the present designation, provisionally, at least.

1.34C14b....1.33A3....1.38P.

DEKAYIA OBSCURA (Ulrich).

Plate XIV, figs. 3, 3a.

Dekayella obscura Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 89, pl. i, figs. 4-4b.

"Zoarium ramose, consisting of slender ramulets, .18 to .25 of an inch in diameter, dividing dichotomously at intervals of .4 inch or more. Monticules are not developed, the surface usually being smooth. Cells from 1-120th to 1-110th of an inch in diameter, with moderately thick walls, and subangular apertures. When in a good state of preservation, the cell-orifices over large patches of the surface are entirely covered, or only partially, by a very thin pellicle or membrane. It is developed from the margin of the aperture inwardly, and when not fully completed, an irregular opening is left in the center. The boundary lines of the cells are now thin, and project but little above the pellicle. The interstitial cells are numerous, and vary much in shape and size, but are always more or less angular. At intervals of about .1 inch, they are usually aggregated into unequal clusters. The spiniform tubuli are of two kinds, large and small, the former may be observed very readily at the surface, and they often show the minute orifice at their summits. About five may be counted in the space of .1 inch. The latter are smaller and much more numerous, and can not be detected except on perfectly preserved examples. They are developed in the cell-walls, and three or four surround each cell.

"In tangential sections the proper cells are subcircular, and have thick walls. Each cell-cavity is encircled by a thin band or ring of dark sclerenchyma, the thinner original walls having a lighter color. The interstitial cells are numerous, unequal and angular, those constituting the clusters or 'maculae' being separated from each other by rather thin walls. The large spiniform tubuli are distinct enough, but the smaller ones can not always be detected. Especially is this the case in examples taken from a shaly matrix. In other specimens they are more apparent.

"Longitudinal sections show that diaphragms, with an occasioal exception, are entirely absent in the axial region, where the walls of the tubes are also very thin. The tubes approach the surface in a gradual curve, and as they enter the peripheral regions, their walls are thickened, sometimes becoming slightly beaded. Very thin straight diaphragms are developed, crossing the tubes at distances apart of from one to one-third tube diameter. The interstitial cells are divided by diaphragms, only a little more crowded than those in the proper zooecia. The large spiniform tubuli make their first appearance in the axial region, and in their course to the surface, they frequently cross obliquely over the tubes (see figure). The smaller ones are first developed in the 'mature' or peripheral region, and can always be seen when the section passes through the face of a tube. The figure on Plate I [of Ulrich's paper] represents two tubes so divided.

"In transverse sections the tubes in the central portion of the branch are slightly larger than nearer the margin. The walls are excessively thin, and polygonal, often nearly circular. Numerous smaller and more angular cells (young) occupy the interspaces left between them. The margin of the section cuts the tubes longitudinally, where they have the same appearance as in the peripheral regions of a vertical section."—Ulrich, *loc. cit.*

This delicate species is the genotype of Ulrich's genus *Dekayella*. It occurs sparingly associated with *D. ulrichi*.

1.34Co, 2, 5, 6. 7, 8, 9.

DEKAYIA PAUPERA Ulrich.

Plate XV, figs. 3, 3a; Plate XXVIII, fig. 6.

Dekayia paupera Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 153, pl. vi, figs. 10, 10a.

"Zoarium ramose, the more or less flattened branches growing upward from a large and thinly expanded base, to a height of one and one-half inches or a little more; varying in thickness from .15 to .3 of an inch, and in width from .2 to .8 of an inch. Surface without monticules. Cells polygonal, with excessively thin walls, the ordinary ones having a diameter of about 1/120th of an inch. At intervals there are distinct groups of large cells, some of which have a diameter exceeding 1/70th of an inch. True interstitial cells are apparently wanting, the few small cells occasionally seen being doubtless young ones. The spiniform tubuli I have not been able to detect at the surface. Pellicle not observed.

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

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

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

1.38P.

DEKAYIA PELLICULATA Ulrich.

Plate XIII, figs. 4, 4a; Plate XXVIII, fig. 5.

Dekayia pelliculata Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 150, pl. vi, figs. 9, 9a.

"Zoarium ramose, with smooth, thick, mostly rounded, sometimes flattened branches, arising from a large basal expansion, and gradually tapering from the base, where the diameter varies from

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

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

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

"This species is distinguished from *D. aspera* externally by its more regularly dendroidal growth, smooth surface (so far as monticules are concerned), and less conspicuous spiniform tubuli.

Internally the much more numerous diaphragms, and interstitial tubes, beside the smaller spiniform tubuli, present weighty points of difference."—Ulrich, *loc. cit.*

I have remarked in my discussion of the genera *Heterotrypa, Oekayia,* etc., that the presence of a pellicle over the mouths of the zooecia does not seem to me to be a character of any especial importance. The species above described, does, however, possess sufficiently distinctive characters, in the form of the zoarium, number of the mesopores and acanthopores, and the presence of close-set diaphragms in the mesopores, to make it valid.

1.34C13....1.38P.

DEKAYIA PROLIFICA (Ulrich).

Plate XV, figs. 4-4b; Plate XXIX, fig. 3.

Heterotrypa prolifica Ulrich, 1890, Geol. Illinois, VIII, p. 413, pl. xxxvii, figs. 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 tuberosites arranged in irregularly intersecting lines and composed of cells a little larger than the average, commonly surrounding a cluster of mesopores, serve to break up the monotony of an otherwise smooth surface. Zooecial tubes curving in the axial region, direct throughout the peripheral region, where the walls become considerably thickened. Zooecia apertures sub-polygonal, about eight in two mm. and 0.15 to 0.18 mm. in diameter. Interspaces occupied by calareous 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 zooecial tubes. Acanthopores a little more than one-third as numerous as the zooecia; when not situated at the angles, generally inflecting the zooecial cavity a little.

"This species approaches quite closely to *H. frondosa* d'Orb., having a somewhat similar growth; but in that species the zooecia 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."—Ulrich, *loc. cit.*

To my mind there is very little difference between this species and *D. frondosa.* The main and almost the only reason for separating them is the difference in range, the latter species occurring only in the Lorraine. It is certain that *D. prolifica* is the Richmond representative of *D. frondosa* of the lower horizon.

1.34A10, 11, 12, 13a....1.41A7, E1, 3, 4....1.12E3.

DEKAYIA SUBFRONDOSA Cumings.

Plate XIV, figs. 6-6c; Plate XXVIII, fig. 10.

Dekayia subfrondosa Cumings, 1902, American Geologist, XXIX, p. 204, pl. ix, figs. 7, 8; pl. x, fig. 3; pl. xi, fig. 1.

"Zoarium growing upward from an expanded cylindrical basal attachment into flat fronds of a thickness of 10 mm. to 15 mm. and a breadth of as much as 60 mm. A specimen nearly complete, except the cylindrical base has a height of 110 mm. The frond has a tendency to give off compressed branches along the free edges. Entire surface covered with small rather abruptly elevated monticules with an average diameter of 1.5 mm.; from 12 to 13 occupy one square centimeter. At the apices of the monticules the cells are smaller than the average. Cells mostly of one kind, 0.25 mm. in diameter, 40 cells to the cm.

"The internal structure of this species as seen in tangential sections is highly instructive. In tangential sections cutting the mature region the cells are seen to be rather thin walled, the walls of adjacent zooecia being apparently amalgamated. That this is not the case is well shown in fig. 8, Pl. X [of above paper] where the section cuts a portion of the zoarium that has been fractured and infilled with calcite along the fracture. The zooecia are spread apart, the wall formerly apparently common to two zooecia being now half on one side, half on the other of the calcite seam. Where an acanthopore is present the zooecial wall separates from it cleanly. Indeed, the acanthopore is sometimes left completely isolated in the calcite, showing that these structures belong to neither zooecial wall. The attention of those who deny the duplex character of the interzooecial wall should be called to this phenomenon.

"Only a moderate number of small tubes are seen throughout the main part of ordinary tangential sections. Fig. 8 Pl. IX [of above paper] shows a cluster of small tubes in a portion of a section in which the walls are also thicker than usual. Tangential sections of the branchlets, however, present almost identically the same appearance as sections of *D. ulrichi robusta.*

"Acanthopores are numerous and conspicuously of two sizes. They are not confined to the angles of the zooecia, but frequently indent their walls.

"Longitudinal sections show that the mature region is very deep, the thickness of the zooecial walls varying but little from where the tubes bend outward, to the surface. The large acanthopores are conspicuous features of such sections. The walls present the beaded appearance characteristic of the genus. This, I believe, is in some cases due to the fact that the section cuts in and out of the side of an acanthopore. The large acanthopores traverse the entire mature region and are sometimes present even in the axial region. Diaphragms are abundantly developed, horizontal or, rarely, curved or infundibular, from one-third to two tube-diameters apart in the zooecia, and closer set in the mesopores. The walls of the latter are constricted where the diaphragms join them."—Cumings, *loc. cit.*

This species seems to me to quite completely break down the line between *Heterotrypa* and *Dekayia* and *Dekayella* as formerly understood. In the form of the zoarium it certainly would be considered as a specimen of *D. frondosa.* The presence of two *well marked* sets of acanthopores would throw it into the genus *Dekayella,* and the absence of mesopores in some regions of the zoarium would suggest *Dekayia.* Tangential sections of the branches can scarcely be distinguished from sections of *Dekayia robusta.*

1.34C13.

DEKAYIA SUBPULCHELLA (Nicholson).

Plate XVI, figs. 1, 1a; Plate XXVIII, fig. 11.

Chaetetes sub-pulchellus Nicholson, 1875, Pal. Ohio, II, p. 196, pl. xxi, figs. 6, 6a.

"Corallum branched, the branches usually hollow, always more or less compressed, and sometimes so much flattened as to become frondescent. Greatest diameter of the branches, from four lines to nearly an inch. The average corallites are circular or polygonal in form, with comparatively thin walls, about eight in the space of one line, with or without a few very minute cylindrical tubuli interspersed amongst them. Intercalated amongst the ordinary corallites are rounded or sub-stellate spaces, about one line in diameter, and placed nearly one line apart, which are occupied by tubes of two kinds. The exterior of each of these spaces is formed by a ring of corallites which are slightly larger than the average, about six of them occupying one line. Inside of this ring is a series of from twenty to forty excessively small cylindrical tubuli, forming a little cluster of pin-like punctures or perforations. The composite clusters of large and small corallites thus constituted are very slightly or not at all elevated above the general surface, and they melt away insensibly at their margins into the ordinary corallites.

This species is closely allied to *C. pulchellus,* Edw. and Haime. but appears to be distinguished sufficiently from it by the flattened and compressed form of the branches, and the composite character of the hardly elevated tubercles, which do not consist throughout of large sized corallites, but have an external ring of large tubes surrounding an internal cluster of very minute tubuli. I have found these characters constant in a large number of individuals, and consider, therefore, that I am justified in describing this form under a distinct title."—Nicholson, *loc. cit.*

The supposed hollow branches of this species are due to the weathering out of the immature region. The figures given herewith will sufficiently indicate the internal characters, which do not differ materially from those of *D. prolifica* except in the greater thickness of the walls and the greater size and number of the acanthopores. The tangential section figured in this report (from a specimen labeled by Ulrich) certainly shows two sets of acanthopores as in the so-called genus *Dekayella.*

1.34C14a.

DEKAYIA SUBRAMOSA (Ulrich).

Plate XV, figs. 5, 5b; Plate XXIX, fig. 2.

Atactopora subramosa Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 124, pl. xii, figs. 6-6c.

"This is not a truly parasitic species, though attached by a broadly expanded base to foreign objects. In certain positions of the bryozoary there appears to have been an excessive growth, the consequence of which was the development of large nodes, or of short and thick branches. Diameter of branches about four lines. Surface without monticules. Tubes small, polygonal, quite irregular in size and arrangement, and with numerous minute intertubular cells; the latter are at irregular intervals collected into groups; of the interstitial tubuli the groups alone are distinguishable on the surface, those interspersed between the ordinary tubes being apparently closed, and can only be detected in thin sections. Tube calices of irregular shape, usually nearly closed by accretions to the margins; in the open calices the margins are thick and smooth; pseudo-septa not invariably developed, few in number, probably never more than three, and generally only one or two in each tube. From eight to ten, or even twelve tubes occur in the space of one line.

"Longitudinal sections show the tubes to be transversely divided by diaphragms, placed at corresponding levels in contiguous tubes. The diaphragms are about two-thirds of a tube diameter apart. The tube walls in the lower portions of the tubes are very thin; they become thicker as the surface is approached. A peculiar feature is the periodic swelling of the walls at heights coincident with the tabulae. In the minute tubuli the diaphragms are more closely set than in the larger tubes.

"It would be quite impossible to confound this species with any other form, since it differs more or less in nearly all particulars from those previously described."—Ulrich, *loc. cit.*

For the identification of this species I have depended principally upon the external form of the zoarium, and the fact that the well-known *D. prolifica* is considered as only a variety of it. The 'pseudo septa' mentioned in the above description are evidently the acanthopores, which more or less indent the zooecia. For the internal characters the student is referred to the figures, and to the description of *D. prolifica.*

1.41E2, and common in the "upper fossil bed" at Versailles.

DEKAYIA ULRICHI (Nicholson).

Plate XIV, figs. 4-4b; Plate XXVIII, fig. 7.

Chaetetes fletcheri Nicholson (non Edwards and Haime), 1874, Quar. Jour. Geol. Soc. London, XXX, p. 504, pl. xxix, figs. 6, 6a. *Monticulipora* (*Heterotrypa*) *ulrichi* Nicholson, 1881, Genus Monticulipora, p. 131, fig. 22, p. 132.

"Corallum ramose, branches from 1½ to 3 lines in diameter, cylindrical or subcylindrical, often irregularly swollen at intervals, dividing dichotomously usually at considerable intervals. Corallites with moderately thick walls, the average ones of unequal sizes, about eight in the space of 1 line, and having very minute tubuli sparingly interspersed amongst them. Surface smooth, destitute of tubercles, but occasionally showing groups of corallites which are very slightly larger than the average.

"The examples of this species which I possess from the Clinton group (Upper Silurian) agrees entirely with the description given by Edwards and Haime, being smooth, and simply having a moderate number of very minute tubes irregularly intercalated amongst the ordinary corallites, these latter varying slightly in their dimensions. On the other hand, the Lower-Silurian examples which I have referred to this species, though also smooth, and also having minute tubuli sparsely interspersed amongst the larger corallites, exhibit distinct groups of corallites which are of rather larger size than the average, and which are not set upon distinct elevations. They thus approach *C. pulchellus,* from which they are hardly distinguishable except by the fact that the groups of large sized corallites are not nearly so conspicuous, the individual corallites which compose them being only very slightly above the average size. On the contrary, in *C. pulchellus* the groups of large-size corallites are very conspicuous, as the corallites composing them are nearly or quite twice as large as the ordinary ones. Perhaps the Lower-Silurian forms here regarded as referable to *C. fletcheri* may constitute a distinct variety either of this or of *C. pulchellus.*"—Nicholson, *loc. cit.*

As is well known now, this species is not the same as the Silurian *Chaetetes fletcheri,* under which name Nicholson described it, as he himself pointed out (Genus Monticulipora, p. 131) when he came to investigate the internal characters.

Its external characters are indicated above, with the exception that a very abundant series of mesopores is usually developed, the zooecia are ring-like, and the acanthopores frequently in well preserved material give rise to minute spines at the surface. The zoaria are characteristically smooth and cylindrical, and of medium size, the specimen figured (after Nicholson) being about typical. As to internal characters, in tangential sections cutting the mature region, the zooecia are seen to be nearly always circular, with moderately thick walls, and surrounded by small angular mesopores. Scattered among the zooecia and imbedded in their walls are a moderate number of acanthopores of two sizes, the greater number being small and not conspicuous, while there are occasional much larger ones, that seem to arise much deeper in the zoarium than the smaller ones, the latter being confined to the mature region. In longitudinal sections the zooecia and mesopores are both seen to be crossed by well defined and complete diaphragms, rather more crowded in the mesopores. These are much less frequent in the axial region. The zooecia bend rather abruptly from the axial into the mature region, and emerge at right angles to the surface, where their walls become considerably thickened.

This species is abundant in the upper part of the Eden Shales (Utica) which it characterizes.

5.9A31, 35, 41, 44....1.34Co, 5, 6, 7, 8, 9, 10, 11....1.38A9, 11, 13, 21, 24, 31, 35, 37, 39, 41, 45, 49, 51, 53, 59, 63, and at all other localities where beds of equivalent age are exposed.

DEKAYIA ULRICHI var. ROBUSTA (Foord).

Plate XIV, figs. 2-2b; Plate XXVII, fig. 22.

Dekayella robusta Foord, 1884, Ann. Mag. Nat. Hist., ser. 5, XIII, p. 341, pl. xii, figs. 2-2d.

"Corallum ramose, frequently branching. Branches thick, usually cylindrical, sometimes compressed. Surface covered with small but tolerably conspicuous monticules, situated about 3 millimetres apart, and bearing cells of a somewhat larger size than those in the intermediate spaces. The apertures of the corallites are polygonal in outline, and in places where the surface is well preserved some of the larger of the spiniform corallites may be seen with a hand lens. Of the larger corallites about four occupy the space of 1 millimetre, of the smaller about five.

"*Microscopic characters.*—Tangential sections reveal clearly the dimorphic character of the corallum, which is provided with two kinds of tubes, large and small; both are of polygonal form, and their outline is inflated in many places by the occurrence of numerous spiniform corallites. These also are of two kinds: The larger are usually situated at the angles formed by the junction of four or five cells, and fill a space quite as great as that occupied by some of the interstitial cells; the smaller are generally found to be in the substance of the cell-walls, about midway between two angles. The spiniform corallites form a very conspicuous feature in tangential sections of this species, and give to such sections a highly characteristic appearance. Under a moderately high power traces of the original walls of the corallites may be discerned in tangential sections; but as a rule this structure appears to have been destroyed in the process of fossilization. In longitudinal sections the two sets of tubes are clearly brought into view. In the larger ones there are numerous horizontal, sometimes slightly oblique, tabulae, situated at from one-half to one tube-diameter apart; they begin in the axial region of the corallum, and are about equally developed in their course from thence to the peripheral region. The smaller tubes do not differ in the character of their tabulation from the larger ones, except that the tabulae in the former are a little more frequent than they are in the latter. There is a feature worthy of note in the structure of the walls of this species, and that is a periodic inflation, which reminds the observer of a similar structure characteristic of the genus *Stenopora* (Lonsdale). Mr. Ulrich draws attention to a like feature in his description of a Cincinnati-group species of *Dekayella—D. obscura,* Ulrich (Journ. Cincinnati Soc. Nat. Hist. vol. vi, p. 150).

"On leaving the axial region the tubes rapidly thicken towards the surface, the spiniform corallites being seen at frequent intervals piercing the corallum and intermingling with the ordinary corallites. The spiniform corallites appear to originate in the axial region of the corallum, as they may be seen in sections cut as deeply as it is possible to make them without destroying the walls of the tubes.

"It may be well here to enumerate the chief characters which separate this species from the only two known to the writer, viz.: *Dekayella ulrichi,* Nicholson, and *D. obscura,* Ulrich—both from the Cincinnati Group of Ohio. From the former of these the present type may be distinguished as follows:—by its much more robust habit of growth, by the possession of monticules, and by the much greater number of its tabulae and spiniform corallites. The exceedingly small and delicate corallum of *D. obscura,* Ulrich, would be sufficient alone to differentiate it from *D. robusta,* and added to this the great development of the tabulae and spiniform corallites in the latter make the distinction between the two forms sufficiently clear."—Foord, *loc. cit.*

The internal characters of this species are substantially the same as those of *D. ulrichi,* and the same as may be seen in similar sections of the branches of the *Dekayia subfrondosa* described by me.

1.34C9, 10, 11, 13.

DICRANOPORA EMACERATA (Nicholson).

Plate XXXII, figs. 13-13b.

Ptilodictya emacerata Nicholson, 1875, Ann. Mag. Hist. 4th ser., XV, p. 179, pl. xiv, figs. 2-2b.

"Polyzoary consisting of minute, narrow, linear fronds, which branch dichotomously, and have the form of a much flattened, acutely pointed ellipse in transverse section. Width one third of a line; length of largest specimen observed, two lines. Cells elliptical, their long axes corresponding with that of the branches, about six or seven in the space of one line measured longitudinally. There are four, five, or rarely six rows of cells in the frond. When four rows of cells are present, two of these (in the centre) are longitudinal, and one row on each side is composed of cells directed in an obliquely ascending manner. When there are five rows, as is most commonly the case, the three central ones are longitudinal and the lateral row on each side is oblique. When there are six rows, two central ones are longitudinal and two on each side oblique. The cell-mouths are much longer than wide, and each row is separated from the next by an elevated line. The lateral margin of the frond on each side forms an obtuse non-celluliferous edge, the width of which is so small that it can not always be detected. A central axis was not clearly determined, but is doubtless present.

"The only previously recorded species of the genus to which *Ptilodictya emacerata* presents any close resemblance is *P. fragilis*, Billings, from strata of the same age in Anticosti (Cat. Sil. Foss. of Anticosti, p. 9). Our species, however, is distinguished from the latter by its uniformly more minute dimensions, the smaller number of rows of cells in the frond, and the possession in genreal of no more than a single row of cells on each side. *P. fragilis*, on the other hand, has a width of from two-thirds of a line to one line, with from eight to ten rows of cells, and two or three rows of oblique marginal cells on each side. It is possible our form is only a variety of *P. fragilis*; but in the absence of figures of the latter, and in the face of the differences above mentioned, I think it safest to regard *P. emacerata* as a distinct species."—Nicholoson, *loc. cit.*

This species is found in nearly every layer of the Liberty formation, in the Tanner's Creek section and in other parts of the Richmond and Lorraine.

1.34A11, 12, 13b, 14, 16b, 17, 18, 19, 20, 21, 22, 23....1.41A4, 5, 6, B1, 3, C1, 2-3, D1, 2, 3, E2, 3, 5, 6, 7....1.12D1-6, E3, F3.

ERIDOTRYPA SIMULATRIX Ulrich.

Plate XVI, figs. 4-4b; Plate XXIX, figs. 5-5a.

Batostomella simulatrix Ulrich, 1890, Geol. Illinois, VIII, p. 432, pl. xxxv, figs. 1-1g.

"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 numerous than elsewhere. Zooecial tubes a little irregular in their course in the axial portion, quite oblique in the peripheral zone where the walls become considerably thickened. Apertures of zooecia oval, owing to the obliquity of the tubes, about 0.2 mm. in their longer diameter and about eight in two mm. measuring longitudinally. Zooecial 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."—Ulrich, *loc. cit.*

This species occurs chiefly near the top of the Waynesville member of the Richmond series, but also sparingly in the succeeding Liberty formation.

1.34A8, 9, 10, 14a, 14b, 15a, 16a, 16b....1.12E3.

ESCHAROPORA ACUMINATA (James).

Ptilodictya acuminata James, 1875, Catalogue of Lower Silurian Fossils of the Cincinnati group, p. 3.

"Polyzoary ensiform; transversely suboval; enlarging very gradually upwards from the pointed base; two series of elevated lines crossing each other diagonally on the upper part, but becoming almost or quite parallel and close together as they near the base, giving to the point a solid appearance. Cells about eight in the space of a line, measuring diagonally; rhomboidal or suboval on the upper part, but become more and more elongated towards the base and disappear before reaching it. A longitudinal elevated line on each side where the diagonal lines meet; somewhat carinate.

"Different examples vary in length from half an inch to more than one inch, and in width, at the broadest part, from three-fourths of a line to one and a half lines; in thickness from one-half to one line.

"The surface of this species resembles *P. falciformis,* Nicholson, but in other respects it differs materially; *P. falciformis* is quite flat, much larger, broader, and thinner, and generally, expands rapidly from the point or base; some specimens are over four inches long, from one-half to three-fourths of an inch wide and only about half a line thick; the edges thin and sharp; exceptional long narrow specimens of *falciformis* are found, but they are very thin and frail. *P. acuminata* approaches in form to a compressed cylinder, is quite convex, rounding to the carinated sides, and expands very gradually from the base.

"It bears some resemblance, also, to *Phaenopora ensiformis,* Hall, from the Clinton group of New York, but differs essentially in the direction of the elevated lines and the nearly solid base."—James, *loc. cit.*

This is probably a narrow and less robust variety of *Escharopora falciformis. E. acuminata* is characteristic of the Eden formation and *E. falciformis* of the lower part of the Lorraine.

5.9A2.

ESCHAROPORA FALCIFORMIS (Nicholson).

Plate XVI, figs. 5, 5a.

Ptilodictya falciformis Nicholson, 1875, Ann. Mag. Nat. Hist., 4th ser. XV, p. 177, pl. xiv, figs. 1-1b.

"Polyzoary consisting of a single, unbranched, or slightly branched, elongated, flattened and two-edged frond, the form of which is curved or falciform, and which gradually expands from a pointed base till it reaches a width of two lines within a distance of less than half an inch above the base. The total length may exceed two inches; but the width, in typical examples, rarely exceeds two and a half lines. The transverse section is acutely elliptical, the thickness in the middle not exceeding half a line; and the flat faces of the frond are very gently curved and not angulated. A central laminar axis, though often undemonstrable, can sometimes be clearly shown to exist. The edges of the frond are thin and sharp, formed by a narrow band, which is marked with longitudinal or slightly oblique striae and by the apertures of minute imperfect cells. Both sides of the frond are celluliferous, the cells being apparently perpendicular to the surface, and being arranged in intersecting diagonal lines, which form angles of about 30° with the sides of the frond, and thus cut one another at about 60°. The mouths of the cells are oval or somewhat diamond-shaped, their long axis coinciding with that of the frond, alternately placed in contiguous rows, about eight in the space of one line measured diagonally; the outermost rows very slightly smaller than the others. Walls of the cells moderately thick; no surface-granulations, tubercles, spines, or elevated lines. The mouths of the cells parallel with the general surface, neither lip being especially prominent, and the plane of the aperture not being oblique.

"As a general rule the polyozoary is simple, unbranched, and falciform. I have seen, however, in the fine collection of Mr. Dyer, of Cincinnati, some specimens in which the frond bifurcates at its distal extremity, and at least one example in which it splits into three divisions. I have also seen examples of what may probably prove to be a distinct species, in which the frond is very much wider than is normally the case.

"This beautiful species is allied to *Ptilodictya* (*Escharopora*) *recta,* Hall, on the one hand, and to *P. lanceolata,* Goldf., *P. gladiola,* Billings, and *P. sulcata,* Billings, on the other hand. The specimens from which the above description is taken were sent to me with the label of *Escharopora recta* attached to them; and at first sight they certainly closely resemble this species, especially in the disposition of the cells in intersecting diagonals of great regularity. It is certain, however, that they are distinct from Hall's species—the chief differences consisting in the fact that the frond of *P. falciformis* is greatly flattened, so that the transverse section is acutely elliptical instead of being 'cylindrical or subcylindrical', whilst the edges are sharp and non-celluliferous, and the entire frond is regularly curved and sabre-shaped instead of being straight. Hall states that *E. scharopora recta* is not branched, but possesses root-like processes. Judging, however, from his figures, it would seem probable that his specimens have been drawn and described in an inverted position, and that this form is in reality dichotomously branched.

"From *Ptilodictya lanceolata,* Goldf. the present species is readily distinguished, more especially by the disposition of the cells, which are in regularly intersecting diagonal lines; whereas in the former there is a central series of longitudinally arranged cells, flanked on each side by diagonal rows directed like the barbs of a feather.

"With *Ptilodictya gladiola,* Billings, our species agrees in the shape of the frond; but it is proportionally twice as wide, whilst the cells are oval instead of being rectangular or oblong, and are disposed in decussating diagonals instead of in longitudinal lines as in the former.

"Lastly, *Ptilodictya sulcata,* Billings, whilst resembling *P. fal-*

ciformis in shape, is distinguished by the nearly square cells with intercellular sulci, and by the fact that the cells are arranged in longitudinal lines."—Nicholson, *loc. cit.*

5.9A41....1.34C13, 14a, 14b.

ESCHAROPORA PAVONIA (Milne-Edwards and Haime) not d'Orbigny.

Plate XVI, fig. 6; Plate XXIX, fig. 6.

Chaetetes pavonia Milne-Edwards and Haime, 1851, Monographie des Polypiers Fossiles des Terrains Palaeozoiques, p. 267, pl. xix, figs. 4, 4a.

"Polypier en lames frondescentes, épaisses seulement de 2 ou 3 millimètres, à mamelons à peine saillants, larges et peu éspaces. Calices polygonaux, souvent tétragonaux, ceux des mamelons plus grands que les autres, et larges d'un tiers de millimètre.

"SILURIEN (inférieur). *Etats-Unis:* Cincinnati (Ohio).

"Coll. d'Orbigny, de verneuil."—Milne-Edwards and Haime, *loc. cit.*

It seems impossible to believe that the form figured by Edwards and Haime (*loc. cit.*) is the same species or even congeneric with the type of *Ptilodictya pavonia* d'Orbigny as recently figured in the Annales de Paleontologie, Tome I, pl. IX (Paris, 1906), and which proves to be the same as the common *Peronopora decipiens* (Rominger). I have therefore, since the two forms fall in widely separated genera, concluded to retain the name *Escharopora pavonia,* crediting it to Edwards and Haime instead of to d'Orbigny. This involves the least change, and I believe there can be no doubt as to the identity of Edwards and Haime's species. It will of course be necessary to substitute *Peronopora pavonia* (d'Orb.) for *Peronopora decipiens* (Rominger). Evidently the specimens in the type lot of d'Orbigny represent at least these two distinct species and possibly more.

In order to supplement the meagre description of Edwards and Haime I quote below the very full description of Nicholson:

"*Spec. Char.*—Corallum forming a thin undulating expansion, often of considerable extent, and varying from half a line to about two lines in thickness. The expansion grew in an erect position, and it consists of two layers of corallites, which have their bases fixed to a medium plane marked by a delicate undulating calcareous membrane, and which open on opposite sides of the corallum. The corallites vary from a quarter of a line to a line in total length, and though oblique at their origin, they almost immediately bend outwards, so as to open nearly at right angles to the general surface, or with only a slight obliquity to it. The calices have the form of elongated pentagons, with rounded angles, their long diameter being from 1-110th to 1-90th inch. Their size is tolerably uniform, and there are no minute interstitial tubes. The calices are often arranged in tolerably regular obliquely intersecting lines; and the surface shows low rounded elevations, which are often obscurely marked, are arranged in diagonal rows at intervals of from a line to a line and a half, and are occupied by calices which are not conspicuously larger or smaller than the average. The walls of the corallites are at first thin; but they rapidly become thickened, the lines of demarkation between adjacent tubes still remaining recognizable. A few remote, complete, and horizontal tabulae are developed in the interior of the tubes; but these are not recognizable in all the corallites, and are often placed at corresponding levels in adjoining tubes.

"*Obs.*—This beautiful species presents a considerable superficial resemblance to *Ptilodictya,* and has been referred to this genus. It wants, however, the definitely circumscribed and peculiarly marked lateral margins of the fronds of this Polyzoan type, and, what is more important, it is without the peculiarly striated central lamina of the *Ptilodictyae.* It is true that the bases of the corallites in *M. pavonia,* D'Orb., [E. & H.] are so united with one another as to give rise to an irregular calcareous membrane, which separates the two halves of the corallum; but none of the specimens that I have seen exhibit any tendency to split along the line of this membrane, nor can the corallites be forcibly removed from one side of it, exposing the median lamina as a definite structure. In both these respects the *Ptilodictyae* would show quite different phenomena. The reasons just given would equally prevent my accepting the view held by Mr. E. O. Ulrich that this form should be referred to *Heterodictya,* Nich., since this genus differs from *Ptilodictya* principally in the possession of tabulae. On the other hand, the general aspect of *M. pavonia,* D'Orb., is not at all remarkably different from that of the thin fronds of *M. frondosa,* D'Orb., while it exhibits low 'monticules'; and there is nothing in its internal structure which is irreconcilable with the view that it is a *Monticulipora.* In the meanwhile, therefore, I shall leave this type within the limits of the genus *Monticulipora,* till more definite evidence may be forthcoming as to its proper position.

"So far as external characters go, *M. pavonia,* D'Orb., is easily recognized by its thin undulated corallum, which carries on both sides the sub-equal, oval, or pentagonal calices, these being often arranged in decussating lines, and elevated at intervals into low and inconspicuous monticules. As regards its internal structure, we have seen that the corallites are bilaterally disposed on the two sides of a central plane, as is shown by vertical sections taken at right angles to the flat surfaces of the corallum. All the corallites are of the same kind, approximately equal, and averaging 1-100th inch in diameter. At first thin-walled, they rapidly have their cavities contracted by a secondary deposit of sclerenchyma. When viewed in tangential sections the visceral chambers of the corallites thus appear to be oval; but the original independence of the corallites is shown by the persistence of the pentagonal boundary lines between adjoining tubes, occupying the middle line of the thickened wall. In these sections the visceral chambers are sometimes encroached upon by a single blunt tooth-like projection on one side; but I can give no precise explanation of this phenomenon. There is no appearance of any interstitial series of tubes between the ordinary corallites, nor are any 'spiniform corallites' present. Tabulae, as seen in long sections, are few in number, sometimes apparently wanting, but, when developed, always complete and horizontal, and often placed at the same level in adjoining tubes, and thus marking stages of growth."—Nicholson, Genus Monticulipora, pp. 195-198, 1881.

To this description should be appended the remarks of Ulrich in regard to the systematic position of the species. After quoting Nicholson to the effect that the form in question lacks the striated margin of *Ptilodictya* and is without the peculiarly striated central lamina of that genus Mr. Ulrich says:

"The first character * * * is, of course, not developed along the growing margin of the fronds, but in all specimens preserving the 'articulating process', the non-poriferous margin may be traced along the edges of the lower portion of the frond. * * * Judging from the above quotation, it would appear that Dr. Nicholson has entirely misconceived the character of the median laminae of the *Ptilodictyonidae.* If I understand him correctly, he believes that the axis is constituted by a *definite structure* from which the two layers of cells may be striped. This impression is manifestly erroneous, nor do I know of a single double-leaved Bryozoan in which such a structure may be demonstrated. In *Ptilodictya* the facts are, simply, that we have two layers of cells which are grown together back to back by the adhesion of the epithecal laminae of each layer. * * *"—Ulrich, Jour. Cin. Soc. Nat. Hist. V, p. 164.

The species has since been referred by Ulrich to the genus *Escharopora**, a genus very nearly related to *Ptilodictya.*

Since *Escharopora pavonia* (E. & H.) is an undoubted Bryozoan, it serves to emphasize the difficulty of Nicholson's position in contending that the *Monticuliporidae* (in the broad sense of older authors) belong to the Corals: for Nicholson referred the form, as will be noted from the above description, to the genus *Monticulipora.*

This species characterizes the lower part of the Lorraine.

1.34C14a, 13....1.38Ba, b.

FENESTELLA GRANULOSA Whitfield.

Plate XXIX, figs. 7, 7a.

Fenestella granulosa Whitfield, 18‹7, Annual Report of the Wisconsin Geological Survey for the year 1877, p. 68. (Not figured.)

"Bryozoum, growing in small fan-shaped or funnel-formed fronds, which rise from a root-like base, by which they have been attached to foreign substances. Longitudinal rays slender, rather closely arranged, and frequently bifurcated; giving to the lower part of the frond a somewhat irregular mode of growth, but becoming more regular above. From three to four of the rays may be counted in the space of one millimetre, in the upper part, but seldom more than three in the lower. Fenestrules subquadrangular, longer than wide, but extremely variable in size and form, and about as wide as the diameter of the rays. Pores small, slightly oval, scarcely exsert, generally four to each fenestrule, one of which is situated at the junction of the transverse dissepiment; rays carinate between the pores; dissepiments narrower than the rays. Non-poriferous surface of the rays convex, distinctly but very minutely granulose, the granules closely and irregularly arranged, sometimes numbering as many as six in the width of the ray opposite the fenestrule."—Whitfield, *loc. cit.*

This is interesting as the oldest form of a type of Bryozoan structure that became predominant in the later Paleozoic. It does not seem to me probable that the various species referred to the genus *Phylloporina* have any ancestral relation to *Fenestella.*

*Geol. Nat. Hist. Surv. Minnesota, III, pt. I, p. 167.

Some of them may bear some such relation to *Polypora.* I should be inclined to look for the ancestors of *Fenestella* in such forms as *Arthroclema* and related genera.

Fenestella cannot be said to be a common species at any horizon, although at one level in the Liberty formation I have seen quite a number of specimens of it.

1.34A12, 13a, 16b....1.41A9, D2, C2-3....1.12D1-6.

GRAPTODICTYA PERELEGANS Ulrich.

Plate XXIX, fig. 8.

Ptilodictya perelegans Ulrich, 1878, Jour. Cin. Soc. Nat. Hist., Vol. I, p. 94, pl. iv, figs. 16, 16a.

"Polyzoary frequently and alternately branched, sharp edged, the branches being acutely elliptical in cross section, about one quarter of a line in thickness centrally, and one and a quarter line wide. Cells covering the surface on both sides, with the exception of a rather broad non-celluliferous border lining the branches. The bases of the cells on the two aspects of the frond are separated by a thin laminar axis. Cell-mouths circular, with a conspicuously elevated rim, arranged in transverse rows, as well as in very regular intersecting diagonal lines, which form an angle of about thirty degress with the sides of the branches; about seven cells in the space of one line measuring both longitudinally and transversely.

"Intertubular spaces quite as wide as the cell-openings, and ornamented, when perfectly preserved, by slightly raised and flexuous lines. The non-poriferous border occupies, on each side, about one seventh of the entire width of a branch, and is marked with very fine, and but slightly waved striae, the direction of which forms an angle of about fifteen degrees with the margin of the branches.

"This beautiful species is allied to *P.* (*Stictopora*) *elegantula,* of Hall, but that species does not branch so frequently, has the cell-mouths val, [oval?] and larger, while the intertubular species [spaces ?] are thinner than they are in this species; the direction of the striae on the non-poriferous margin of Hall's species, forms a much larger angle with the edge of the branch than it does in *P. perelegans.*"—Ulrich, *loc. cit.*

1.34A8.

HELOPORA ELEGANS Ulrich.

Plate XXIX, fig. 9.

Helopora elegans Ulrich, 1893, Geol. Nat. Hist. Surv., Minnesota, p. 194, fig. 11.

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

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

1.34A12....1.41A4, D2.

HELOPORA HARRISI James.

Plate XXIX, figs. 10-10b.

Helopora harrisi James, 1883, The Paleontologist, No. 7, p. 58, pl. ii, figs. 3, 3a.

"The numerous well defined sections of this species, lying upon and embedded in the surface of a small slab of limestone, examined for this description, consist of delicate stems, with generally a single row of much elongated oval cells, on the *exposed* face, but occasionally—seldom—two rows are shown; the number of rows of cells on any one section undetermined, two at least, and may be three or four on some or all specimens; the difficulty in ascertaining this point definitely is in not being able to obtain detached examples, owing to the extreme delicacy of the stems; in removing them from the slab they crumble into small particles. The fragments or sections of branches are from one to two lines in length, and from 1-8th to 1-10th of a line in breadth, with about 6 of the oval elongated cell apertures to one line. Sides of the specimens drawn together at the ends of apertures, giving them a chain-like appearance, resembling, somewhat, a transverse section of a single row of tubes of Halysites; sometimes this feature is less pronounced than in most cases, the sides then being nearly parallel, and not drawn in or but slightly so. Occasionally the sections show swollen terminations. They are, no doubt parts or joints (?) of a Polyzoary of considerable size, as indicated by the profusion of fragments on both sides of the slab about 4x4½ inches.

"Exceedingly fine longitudinal lines may be seen on the general surface, with a good lens.

"This species differs from *Helopora tenuis* [*Arthrostylus tenuis*], James, in the elongated instead of circular cell apertures, the constrictions between the cells, and the absence of a striated nonporiferous face as shown on one side of that species; also in the larger size of the stems."—James, *loc. cit.*

The above description is incorrect in a number of details. I quote therefore parts of the excellent description by Ulrich (Geol. Minnesota, III, 1893, p. 195):

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

Reported from various Indiana localities by Ulrich.

HOMOTRYPA AUSTINI Bassler.

Plate XVI, figs. 7-7b; Plate XXIX, figs. 11, 11a.

Homotrypa austini Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 584, pl. xxiv, figs. 5-9.

"The branches of this neat species are small, cylindrical, 4 to 8 mm. in diameter, and divide rather frequently. Surface smooth. Zooecia small, polygonal to rounded, thick walled, nine to ten in 2 mm. Acanthopores numerous, four or more often surrounding a zooecium and generally visible at the surface as blunt spines.

Mesopores, except an occasional one in the maculae, wanting. The zooecia in the axial region are without diaphragms and have thin, crinkled walls, the greatest amount of crinkling occurring just before the peripheral region is reached. As a rule, both cystiphragms and diaphragms are absent in the peripheral region of the ordinary zooecia, but in those of the maculae there is an abundance of the former.

"This species is named after its discoverer, Dr. George M. Austin, of Wilmington, Ohio, who, notwithstanding arduous professional duties, finds time for enthusiastically collecting and studying the fossils of that region."—Bassler, *loc. cit.*

To this species I have referred a number of specimens having small smooth zoaria and an almost total absence of Cystiphragms or diaphragms. These depart in certain particulars from the typical *H. austini*, as described by Bassler, but I am not at present prepared to make any other disposition of them.

1.34A16, 19-21....1.41D1, 2, E1, C1....1.12E3.

HOMOTRYPA COMMUNIS Bassler.

Plate XVII, figs. 1-1d; Plate XXIX, fig. 12.

Homotrypa communis Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 581, pl. xxiii, figs. 1-4.

"Zoarium of subcylindrical or more commonly compressed branches from 5 to 10 cm. high and 4 to 8 mm. in thickness. Surface smooth, with clusters composed of larger cells and mesopores. Apertures direct, polygonal, rather thick-walled, with about nine in 2 mm. Acanthopores seldom seen on the surface, but sections show a zooecium to be surrounded by from four to seven. Walls thin and crinkled in the axial region, much thickened in the peripheral. Diaphragms wanting in both regions. Cystiphragms few, generally restricted to the region transitional to the mature condition.

"Externally this species sometimes resembles *H. curvata*, but internally is very different. The only associated form with which it might be confounded is *Bythopora meeki* (James), which often bears a superficial resemblance. Sections show the two species to be very distinct."—Bassler, *loc. cit.*

1.34A11, 12, 13a, 14a, 14b.

HOMOTRYPA CONSTELLARIFORMIS n. sp.

Plate XVII, figs. 2-2b.

The zoaria of this interesting species are small, subcylindrical, to cylindrical, smooth stems with star-shaped groups of mesopores, giving to the surface much the appearance of *Constellaria limitaris,* but with the mesopores much less numerous and less regularly arranged. The mesopores sometimes run out from the center of the macula in chains between which are peculiar sinuous channels, unlike anything known to me in any other species of the Trepostomata. In some cases the maculae seem to be entirely composed of these peculiar channels. This feature gives to the surface a most extraordinary and beautiful appearance. In tangential sections the maculae are seen to be composed entirely of small mesopores and the chain-like arrangement is also apparent here. The ordinary zooecia are fairly thin-walled, about as in *H. flabellaris,* and are usually occupied by the cut edges of cystiphragms. Acanthopores are few and of small size. Mesopores are few or lacking outside of the maculae. In longitudinal sections are seen numerous well developed cystiphragms and diaphragms in the mature region and an occasional diaphragm in the immature region, the zooecia curve gradually into the mature region and emerge at right angles to the surface. In the specimen figured the mature region has been duplicated by overgrowth. This does not seem to be a general character of the species.

The majority of the specimens were obtained from the base of the Whitewater division in the railroad cut north of Weisburg Station, and loose from the top of the first cut south of the station. A single specimen was found in the "upper fossil bed" at Versailles (Whitewater).

HOMOTRYPA CURVATA Ulrich.

Plate XVII, figs. 3-3b; Plate XXIX, fig. 13.

Homotrypa curvata Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 242, pl. x, figs. 7-7d.

"Zoarium ramose, consisting of compressed, often greatly flattened branches. An average specimen has a height of over two inches, a width of about seven tenths of an inch, and a thickness of two tenths of an inch. The most conspicuous feature of the surface is found in the small, stellate maculae, which, under a low magnifying power, appear to be solid, but, as is shown by a higher power, are composed of very shallow, and angular, small cells. These maculae are on a level with the general surface, and occur at intervals of about .11 of an inch, measuring from center to center. The ordinary cells are usually rounded, though sometimes slightly angular, have moderately thick walls, with a diameter varying from 1/140th to 1/130th of an inch. The cells immediately surrounding the stellate maculae are larger, and may attain a diameter of 1/90th of an inch. When the specimen examined is in a good state of preservation, the surface spines (spiniform tubuli) may be detected. They never constitute a conspicuous feature of the surface.

"Tangential sections show that the tubes in the outer or 'mature' portion of the zoarium have thickened walls, more or less rounded visceral cavities, and that they are apparently completely amalgamated with one another. The walls, between the narrow lucid ring which surrounds each of the tubes, has a peculiar granular structure, and is crossed by the connecting foramina, of which my sections show three or four to enter each tube. The spiniform tubuli are numerous, of moderate size, and have the usual appearance. In longitudinal or vertical sections the tubes in the axial region have excessively thin, and slightly flexuous walls, and are crossed by diaphragms at distances apart of from one to two tube-diameters. As they bend outward into the peripheral region, their walls are much thickened, the diaphragms occur at shorter intervals (one-third to one-half a tube-diameter), and correspondingly crowded series of cystoid diaphragms are developed in nearly all the tubes. Lastly, the spiniform tubuli may be recognized.

"In transverse sections the tubes are polygonal, the walls excessively thin, and the calcite filling them is divided by irregular cruciform lines, that often are so distinct as to cause the observer some trouble to exactly determine the outlines of the tube walls. (The same feature occurs in many other species of the *Monticuliporidae.*)"—Ulrich, *loc. cit.*

1.33A3....1.34A11, C13, 14a....1.38Ba.

HOMOTRYPA CURVATA var. PRAECIPTA Bassler.

Plate XVIII, fig. 4; Plate XXX, figs. 7, 7a.

Homotrypa curvata var. *praecipta* Bassler. 1903, Proc. U. S. National Museum, XXVI, p. 575, pl. xxiii, fig. 15.

"This varietal name is proposed for the only *Homotrypa* known in the Utica. It has the internal characters of *H. curvata,* but differs in the growth of the zoarium. Its branches are cylindrical, smooth, about 6 mm. in diameter, and divide at short intervals, while the zoarium of *H. curvata* takes the form of broad, compressed branches, dividing at less frequent intervals. Thin sections show that the Utica form generally exhibits more acanthopores, but the number of acanthopores varies slightly in every species."—Bassler, *loc. cit.*

This form was first noted by the writer in 1902* as occurring in the upper Utica; and is reported by Bassler (*loc. cit.*) from the middle Utica. It also occurs in the lower Lorraine.

1.34C13.

HOMOTRYPA CYLINDRICA Bassler.

Plate XVII, figs. 4, 4a; Plate XXIX, fig. 14.

Homotrypa cylindrica Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 585, pl. xxii, figs. 8-13.

"Zoarium ramose, branches long, cylindrical, from 4 to 15 mm. in diameter, dividing dichotomously at intervals of from 3 to 4 cm. Surface varying from smooth to tuberculated, the maculae or monticules generally somewhat transversely elongated. Zooecial apertures thick walled, usually angular, direct, about nine in 2 mm. Mesopores few, seldom occurring outside of the clusters. Only well-preserved examples show at the surface the numerous and very large acanthopores characteristic of the species. The walls of the zooecia in the axial region are thin and but little crenulated, but in the mature region they become so thickened as to almost equal in breadth the diameter of the zooecial cavity. Cystiphragms well developed. Diaphragms very few, if present at all, the structures simulating them probably being large cystiphragms.

"The large and numerous acanthopores and the thickness and minute structure of the walls give a very characteristic, even bizarre, appearance to tangential sections. The number of acanthopores varies, the normal number being four to five when they are large to five to nine smaller ones around a zooecium. In vertical sections the acanthopores are seen not only to proceed directly to the surface parallel with the zooecial walls, but they also sometimes cross them obliquely."—Bassler, *loc. cit.*

1.41A7, 8, D3, E3, 4, 5....1.12F3.

HOMOTRYPA DAWSONI (Nicholson).

Plate XVII, figs. 5, 5a; Plate XXX, fig. 1.

Monticulipora (*Heterotrypa*) *dawsoni* Nicholson, 1881, Genus Monticulipora, p. 141, pl. v, figs. 3-3f.

"*Spec. char.*—Corallum having the form of an undulated expansion, of unknown size, and about two lines in thickness. Surface covered with numerous close-set prominent monticules, which are markedly elongated, are placed about a line, or less, apart, and are occupied by corallites which do not differ conspicuously in

*Cumings, American Geologist, XXIX, p. 215, foot note.

size from those forming the mass of the corallum. Calices polygonal, thin-walled, about 1-90th inch in diameter, without any regular series of small apertures, but occasionally exhibiting at their angles of junction a minute circular opening. Normal corallites sub-equal, polygonal, at first thin-walled, but becoming slightly thickened as they approach the surface. In the center of the flattened corallum they are furnished with delicate, wavy, or crimped walls, and are vertical in direction, being in this part of their course entirely free from tabulae. They then gradually bend outwards, with a very slight inclination, their walls becoming at the same time thickened, and a moderate number of complete horizontal tabulae being developed.

"In addition to the normal corallites (which are mostly of one kind) there are numerous thick-walled, circular tubuli ('spiniform corallites') developed at the angles of junction of the former, or in the thickness of their walls.

"*Obs.*—In its general form, mode of growth, and external appearance, this species might perfectly well pass as an example of either *M. mammulata,* D'Orb., or *M. molesta,* Nich. The only superficial characters which would lead to its separation are, that the normal calices are not intermingled with a series of smaller apertures, and that the prominent monticules are certainly more elongated and compressed than is usual in examples of the above. In its internal structure, however, *M. Dawsoni* is fundamentally different from either *M. mammulata,* D'Orb., or *M. molesta,* Nich., and exhibits a quite peculiar assemblage of characters.

"In tangential sections the corallum is seen to be composed almost wholly of one series of normal corallites, which are similar in internal structure, and approximately equal in point of size. Near to the surface, the walls of these corallites are moderately thickened, though the lines of demarkation between adjoining tubes are not obliterated; and they are uniformly polygonal in shape. Only an occasional interstitial corallite, properly socalled, is present; but there are numerous minute, circular, thick-walled, darkly-outlined tubuli ('spiniform corallites'), the apertures of which upon the surface may occasionally be detected. So far as can be made out, the corallites of the monticules are in no important respect different from those making up the bulk of the corallum; though this point is one difficult to settle absolutely, as a tangential section necessarily cuts the tubes of the monticules at a lower level than it intersects those of the corallum generally, and therefore exhibits the former at a point where their walls are relatively thinner.

"Vertical sections taken at right angles to the plane of the frond, show that the precise arrangement of the tubes differs from what is observable in *M. frondosa* D'Orb., on the one hand, and in *M. mammulata,* D'Orb., and *M. molesta,* Nich., on the other hand. In *M. frondosa,* D'Orb., the corallites of the two sides of the colony spring from the opposite sides of a more or less complete calcareous lamina, which occupies the mesial plane of the colony, and which is seen in a still more perfect form in *M. pavonia,* D'Orb. In *M. mammulata* D'Orb., and *M. molesta,* Nich., again, the corallites of the two halves of the corallum have their origin in an apparently irregular mesial mass of cellular tissue, formed by the bases of the tubes, and there is no sign of any central lamina. In the present species no central lamina exists, but the tubes are quite vertical in the middle line of the frond, each bending outwards, with a very gradual inclination to reach the surface on one side or the other. In the vertical portion of their course, the corallites are thin-walled, and their walls are wavy or are sharply undulated from side to side, and I have not been able to detect any tabulae in this region. In the outer part of their course, on the other hand, the walls are somewhat thickened, while a moderate number of tabulae are now developed. There is mostly no difference observable in the tabulation of the corallites, though here and there a small-sized tube with close-set tabulae may be detected; and the tabulae are in all cases complete and approximately horizontal.

"The only two species of *Monticulipora,* known to me, with which the present form could be confounded, are *M. mammulata,* D'Orb., and *M. molesta,* Nich.; and the differences in its minute structure, as above described, are so marked as to render it unnecessary to compare it in detail with either of these types.

It is to be remembered that the *Monticulipora mammulata* of Nicholson is the *Dekayia frondosa* of the present paper, and that *M. frondosa* mentioned in the above discussion is the form now known as *Peronopora decipiens,* or *Peronopora pavonia* as it should now be called.

Nicholson failed to discover the really important characteristic of his *Monticulipora dawsoni,* namely the presence of cystiphragms. This important feature was pointed out by Ulrich in 1882* with the suggestion that Nicholson's section probably was prepared from a portion of a frond not fully matured. Bassler† has recently published very good figures of a tangential and longitudinal section of

*Ulrich, Jour. Cin. Soc. Nat. Hist., V, pp. 241, 242.

†Bassler, Proc. U. S. National Museum, XXVI, p. 581, pl. XXV, figs. 9, 10.

the species. These with the present illustrations will serve, in connection with Nicholson's very full description, to indicate the form and internal characters of this rather rare species.

1.41E6, and from the Waynesville formation near Brookville, Indiana.

HOMOTRYPA FLABELLARIS Ulrich.

Plate XVIII, figs. 1-1b; Plate XXX, fig. 2.

Homotrypa flabellaris Ulrich, 1890, Geol. Illinois, VIII, p. 411, pl. xxxii, figs. 3-3c.

"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 maculae about four mm. apart, measuring from center to center. Peripheral portion of zoarium narrow. Walls of zooecial tubes flexuous or crenulated in the axial region, and very thin even in the cortical region. Zooecia apertures angular, slightly oblique, from eight to ten in two mm., those in the maculae from a third to a half larger than the average. Mesopores few, gathered into clusters in the maculae. Zooecial 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 maculae 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."—Ulrich, *loc. cit.*

In the majority of well matured specimens from Indiana localities, seen by me, the mature region is fairly deep, with well developed series both of cystiphragms and diaphragms. The walls are rather thin, even in the mature region, and acanthopores are moderately well developed. The most characteristic surface feature is the maculae of larger zoöecia, among which a considerable number of mesopores are distributed, often radiating out from the center of the macula, so as to give the latter a somewhat star-like appearance. Some of the specimens in the writer's collection have low, rounded monticules. The latter are not as conspicuous as in the variety, *frondosa*. The typical *H. flabellaris* is an abundant fossil in the middle members of the Richmond series.

1.34A12, 13a, 14a, 14b....1.41A2, 6, 7, 8, B1, D1, 3, E1, 2, 3, 4, 6.

HOMOTRYPA FLABELLARIS var. FRONDOSA Cumings.

Plate XVIII, figs. 3-3b; Plate XXX, fig. 3.

Homotrypa frondosa (Edwards & Haime) Cumings, 1902, American Geologist, XXIX, p. 208, pl. x, figs. 11, 12; pl. xi, figs. 2, 5; pl. xii, fig. 1.

"Zoarium frondescent, wavy, 4 to 6 mm. thick and 30 to 50 mm. or more in width. The surface is studded with large rounded stellate monticules which are sometimes slightly elongated in the axial direction of the frond. Monticules usually well elevated, never conical, somewhat spreading at the base. On an average, nine occupy a space of one square centimeter. They are 2 mm., to 2.5 mm. in diameter, and occupied by cells larger than the average. Ordinary cells very uniform in size, 0.2 mm. in diameter; the diameter of the large cells in the monticules is frequently as much as one-third mm. Fifty cells of the ordinary size may be counted in one cm. An occasional mesopore may be detected at the angles of the zooecia.

"The internal structure of this species is that of a typical *Homotrypa* (cf. *H. curvata*). In tangential sections, taken near the surface, the cells are thick-walled, with distinct true walls, and copious deposit of sclerenchyma. The large cells of the monticules are a conspicuous feature of such sections. Only an occasional acanthopore can be detected.

"Longitudinal sections show that the zooecial walls in the axial region are thin, slightly wavy, and that diaphragms are here lacking. In the mature region the walls become greatly thickened, the true walls being seen as a double dark median line. A series of overlapping cystiphragms is present in practically every tube, and horizontal diaphragms in moderate number cross from the backs of the cystiphragms to the opposite wall. The cystiphragms are usually of the concave but are occasionally on the convex side of the wall. In fig. 12, Pl. X. [of the above paper], a very large zooecium is shown at *a* and a splitting of the interzooecial wall at *b*, which may very well produce on the surface the effect of lines radiating from the apices of the monticules, causing them to appear stellate." —Cumings, *loc. cit.*

As will be seen under the discussion of *Dekayia frondosa* (q. v.) this is not the *Monticulipora frondosa* of d'Orbigny, as the writer thought at the time the above description was written. This fact only goes to show the utter impossibility of making a satisfactory identification of species of Trepostomata on the basis of external characters alone.

Homotrypa frondosa is very close to *H. flabellaris* and ought to stand as a variety of that well known species. Its well developed monticules and almost total absence of acanthopores are sufficient to distinguish it.

1.34B4-5.

HOMOTRYPA FLABELLARIS var. SPINIFERA Bassler.

Plate XVIII, fig. 2.

Homotrypa flabellaris var. *spinifera* Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 580, pl. xxi, figs. 11-15.

This variety agrees with *H. flabellaris* in all essential characters save one, namely, that at rather regular intervals among the zooecia very large acanthopores are developed, the place of a zooecium often being occupied by one. This gives the otherwise smooth surface of the zoarium a spiny aspect. The acanthopores often originate in the axial region and proceed to the surface irrespective of the course of the zooecia."—Bassler, *loc. cit.*

1.41A6, 8, E1, 3, 6, 7, D3.

HOMOTRYPA NICKLESI Bassler.

Plate XVIII, figs. 6, 6a; Plate XXX, fig. 4.

Homotrypa nicklesi Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 586, pl. xxii, figs. 4-7.

"In growth and external features this species resembles *H. communis,* but is readily distinguished by the less robust growth and the tendency to branch more frequently. The internal structure further distinguishes the two, since *H. nicklesi* is of the *H. curvata* group, while *H. communis* is of the group to which it gives its name. Surface smooth, with regularly disposed maculae of larger cells and mesopores. Zooecia with moderately thick walls, about nine in 2 mm. Acanthopores not present at the surface and usually also absent in sections. Diaphragms absent in the axial region, appearing in the transitional zone to the peripheral region and increasing in number toward the surface. Cystiphragms in a moderately crowded series in the peripheral region.

The well-developed diaphragms and cystiphragms and the almost complete absence of acanthopores, together with the growth and surface features, characterize this species. The specific name is in honor of Mr. John M. Nickles, who collected the species."—Bassler, *loc. cit.*

1.41E3.

HOMOTRYPA NITIDA Bassler.

Plate XVIII, figs. 5, 5a; Plate XXX, figs. 5, 5a.

Homotrypa nitida Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 586, pl. xxv, figs. 5-8; pl. xx, fig. 15.

"Zoarium of small frequently branching, more or less cylindrical stems, usually 4 or 5 mm. in diameter. Surface smooth. Maculae large, composed of zooecia, which are often twice the diameter of the ordinary cells; 10 zooecia in 2 mm. Diaphragms few in the axial region, not very abundant in the peripheral region, where also the cystiphragms are large but not abundant. Acanthopores small, few, usually wanting.

"This species is closely related to *H. gelasinosa,* and may be only a variety of that form. The larger maculae and acanthopores and flabellate growth of the latter are deemed of sufficient value to distinguish it from *H. nitida.*"—Bassler, *loc. cit.*

Reported by Bassler from the Richmond formation, near Osgood, Indiana.

HOMOTRYPA OBLIQUA Ulrich.

Plate XIX, figs. 1-1b; Plate XXX, fig. 6.

Homotrypa obliqua Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 243, pl. x, figs. 6, 6b.

"Zoarium ramose, branches cylindrical or compressed, from two to four-tenths of an inch in thickness. Typically the surface is covered by rather prominent and closely arranged monticules, the summits of which carry cells with thicker walls than the average. The monticules are not a constant feature in this species, examples with an almost entirely smooth surface being of frequent occurrence. The ordinary cells are polygonal, have rather thin walls, more or less oblique apertures, and a diameter varying from 1/120th to 1/110th of an inch. In the axial region the tubes are thin-walled, polygonal, subequal, without diaphragms, and almost vertical in direction, as they pass into the peripheral region, bending outward very gradually, their walls become thickened, and a moderate number of both straight and cystoid diaphragms are developed. The tubes appear to be of one kind only. Tangential sections show, often in a very distinct manner, the connecting foramina, and a structure of the tube walls precisely similar to that of *H. curvata.* The spiniform tubuli are small, and more or less numerous, but never conspicuous, and developed at the angles of junction of the cells, or in the substance of their walls.

"In its typical form this species may be readily distinguished from the preceding by its tuberculated surface. The more nearly smooth examples can be distinguished by the thicker cell walls, stellate maculae, and the much more flattened branches of *H. curvata.*"—Ulrich, *loc. cit.*

1.33A3....1.34B1-3, C14....1.38Ba-h.

HOMOTRYPA RAMULOSA Bassler.

Plate XIX, figs. 2-2b; Plate XXX, fig. 8.

Homotrypa ramulosa Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 585, pl. xxv, figs. 1-4.

"Zoarium consisting of subcylindrical or somewhat compressed stems from which branches proceed frequently and without regularity; an average example is 8 cm. high and 8 to 12 mm. in thickness. Surface with low broad monticules, the center of each usually occupied by a star-like cluster composed of mesopores only and surrounded by cells slightly larger than the average. Apertures polygonal, direct, ten to eleven in 2 mm. Mesopores restricted almost entirely to the clusters. Acanthopores few and rather small, although now and then one of large size may be present, and these in vertical sections have thin transverse partitions. Diaphragms are developed in the zooecial tubes as the peripheral region is approached and are quite numerous near the surface. Cystiphragms of rather small size line the tubes as usual in the peripheral region; in a tangential section they appear much less curved than is generally the case, sometimes showing as a straight line across the cell cavity.

"The small cells and much branched growth externally, and the strong development of both diaphragms and cystiphragms in the peripheral region, are characteristics which readily distinguish this from other Richmond species."—Bassler, *loc. cit.*

1.34A11, 12....1.41A8, B1, E4....1.12E3.

HOMOTRYPA WORTHENI (James).

Plate XIX, figs. 3-3c; Plate XXX, fig. 9.

Monticulipora (*Monotrypa*) *wortheni*, James, 1882, The Paleontologist, No. 6, p. 50. Pl. I, fig. 2.

"Corallum consisting of cylindrical or flattened stems, from one to two lines in diameter, branching at irregular intervals, sometimes dichotomously; surface occupied by small, prominent monticules, arranged in alternating, longitudinal rows, about one line apart; calices subcircular or angular, from 10 to 12 in the space of one line. Slopes of monticules occupied by calices of the ordinary size or slightly larger, but the apices are, apparently, solid. No interstitial tubuli observed in the specimens examined. Margins of apertures of corallites tolerably thick.

"In a longitudinal section of the *interior* the tube walls are very thin, simple and somewhat wavy or tortuous, with a gentle outward inclination each way from the axial part, but near the surface the outward curve is more rapid, and the walls much thickened, showing a duplex character; the tubes opening at the surface more or less obliquely. No tabulae observed in the central region, and but few in the outer part of the thickened walls. In *tangential* section the cells are suboval, or subcircular, thick walled, and each surrounded by a distinct open space; faint indications of small 'spiniform' corallites distributed, sparsely, at the angles of some of the larger tubes. A *transverse* section shows the very thin walls of the corallites in the central region, of various angular shapes, and the sudden thickening of the walls, and duplex character, and few direct, horizontal tabulae near the surface.

"*Externally,* at first sight, this species resembles *M. ramosa,* D'Orbigny var. *dalei,* E. & H., but when examined under a magnifier the marked difference is apparent. *Internally,* they differ widely."—James, *loc. cit.*

This description indicates fairly well the chief external characteristics of this species of *Homotrypa,* but fails to bring out the really important internal characters. For the latter, I quote the recent excellent description by Bassler in his paper on the genus *Homotrypa:*

"In tangential sections the striking characters are the thick walls, numerous acanthopores, and wide intermural space with its dotted structure. Here also communication pores are well shown. Vertical sections show that the walls in the axial region are thin and rather straight, but become greatly thickened in the peripheral, where a series of cystiphragms larger than usual is developed with a corresponding number of diaphragms.

"The sharply tuberculated branches of this * * * species readily distinguish it from associated forms."

1.34A13a, 16....1.41A7, 8, 10a, D3, E1, 2, 3, 6.

This species is abundant in the Whitewater division of the Richmond formation, which it characterizes. It is found abundantly in the "upper fossil bed" on the west fork of Cedar Creek at Versailles, in association with other Whitewater species. This bed, it will be remembered, is *above* the shale bed and the coral reefs that mark the base of the Saluda.

HOMOTRYPA WORTHENI var. PROMINENS Bassler.

Plate XXX, fig. 10.

Homotrypa wortheni var. *prominens* Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 584, pl. xxiv, figs. 15, 16.

"The very prominent, elongated monticules will distinguish this variety. The zoarium also differs from the cylindrical branches of *H. wortheni* by forming broader, subcompressed to flat fronds. Internally the variety and species are practically identical."—Bassler, *loc. cit.*

This form is reported by Bassler as abundant in the highest beds of the Richmond along Elkhorn Creek near Richmond, Indiana. I have also found it at the same place and in the top of the Tanner's Creek section.

Elkhorn.

HOMOTRYPELLA cf. RUSTICA Ulrich.

Plate XIX, figs. 5, 5a; Plate XXI, fig. 4; Plate XXX, fig. 11.

Homotrypella rustica Ulrich, 1893, Geol. Nat. Hist. Surv. Minnesota, III, pt. I, p. 234, pl. xviii, figs. 31-33.

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

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

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

The above description applies to a specimen from Minnesota. In his citation of localities Ulrich mentions the fact that he had applied in manuscript the name *rustica* to a common species occurring in the upper beds of the Cincinnati group in the Cincinnati region. The latter is, I take it, the species which I have collected in considerable numbers in the Whitewater division at Richmond, and about Laurel and Versailles, Indiana. The Indiana specimens are altogether more robust than the Minnesota specimen, and the acanthopores are more numerous, and commonly indent the zooecia, so that at the surface the latter present an appearance very much like what is commonly seen in species of *Atactoporella,* to which genus the writer at first supposed the specimens to belong, until the zoarial characters were more fully understood. The species is far too common to have been overlooked by as expert a collector as Mr. Ulrich, and I consequently entertain no doubt but that I am right in referring the specimens in my collection to the above species. No other species with which it is associated can possibly be confused with it, and further comparison is therefore unnecessary.

1.41E2, 3, 4, 5, 6, 7, A5, 6, D1, 2, 3....1.60H11, and in addition at several localities, associated with *Rhynchotrema dentata,* in the vicinity of Laurel, Indiana, and in the "upper fossil bed" in the section on the west fork of Cedar Creek, north of Versailles (No. 11 of the section).

LEPTOTRYPA CALCEOLA (Miller and Dyer).

Plate XX, figs. 1-1c.

Monticulipora calceolus Miller and Dyer, 1878, Jour. Cin. Soc., Nat. Hist., I, p. 26, pl. i, figs. 11, 11a.

"This little coral, so far as our observation has extended, is always found in the shape of a little wooden shoe. For the purpose of describing it, we will regard the upper end, as shown in the figure, as the anterior, and the lower as the posterior; and from the assistance furnished by a longitudinal microscopic section, kindly prepared for our use by Dr. J. H. Hunt, we are enabled, as we think, to define the manner of its growth.

"We may suppose a single embryo from an egg, or in the form of a ciliated anamalcule, floating free in the waters of an ocean; then becoming a simple bryozoon, and secreting a single, calcareous, cup-shaped cell, and forming for itself an epithecal covering for its base. It now increases by gemmiparous reproduction, each little bryozoon attaching itself by a point to the parental extension of the epithecal covering, and gradually enlarging its cup-shaped cell by the side of its parent. We now have the commencement of this coral at the upper side of the anterior end. This method of growth at once forms a concave base, which is prolonged into a circular expanding cup. The bryozoa upon the lower side, instead of attaching themselves by a mere point to the epithecal covering now secrete this material for part of the side of each cup, and thus form each individual cell into a little horn-shaped cavity, upon the concave side of which other bryozoa attach. The result of this method of growth is the extension of the expanding cup-shaped basal cavity, formed by the multiplicity of bryozoa, into a circular-horn shaped cavity, with the mouth at the posterior end as shown in the illustration.

"The epitheca is thin and concentrically wrinkled. The corallites are subequal in size, the larger ones collected into groups. They are thin walled and arranged in diagonal lines, somewhat like the arrangement in *Monticulipora quadrata*. The calices are hexagonal, polygonal, round or otherwise variable in form (though the hexagonal ones seem to be the most common), and measure from 8 to 12 in the space of a line. The larger calices are sometimes gathered into tubercles, while other specimens are free from these elevations. Specimens vary from 1-5th to 3-5ths of an inch in length, and from 1-6th to 1-3d of an inch in width, and appear to have always been free from attachment to other substances.

"This species we separate from all others by its form and method of growth. We regard it as belonging to the class bryozoa, because regular calcareous partitions or tabulae are not found in the microscopic sections, and because we believe its method of growth was gemmiparous, and that each animal resided in a separate cell. It may be that the genus *Monticulipora* belongs to the true polyp corals, and if so, it may be that our species should be arranged in a new genus, but we prefer to leave it in this genus rather than attempt to found another without special study of all the Silurian forms.

"This species is not uncommon on Mount Auburn, at an elevation of about 400 feet above low-water mark at Cincinnati."—Miller and Dyer, *loc. cit.*

Miller and Dyer were mistaken in their statement that this species does not possess tabulae, as is shown by Nicholson's sections reproduced herewith. As to the manner of growth, it seems to be the general opinion of those who have studied numbers of specimens of the species that in spite of its suggestive shape, it did not grow on foreign bodies, and that the basal membrane is a true epitheca.

1.34C13 (?).

LEPTOTRYPA CLAVACOIDEA (James).

Plate XX, figs. 3-3c.

Chaetetes clavacoideus James, Catalogue of the Lower Silurian fossils of the Cincinnati group, 1875, p. 1.

"Corallum clavate, cylindrical; in some cases expanding upwards, others tapering, and others of nearly uniform size the whole length; surface, generally, without tubercles; calices polygonal and from eight to twelve in the space of a line, sometimes with groups of larger size than the average; walls of corallites thin.

"The examples of this species so far examined are built upon the tapering ends of very small orthocera; cut transverse and vertical sections show the corallites radiating at right angles with the longer axis of the corallum and arching over at the apex. In some cases the central object has decayed, leaving the corallum hollow or filled with clay. Diameter of different specimens from four to eight lines; length from one to two inches, or more. I have one specimen showing small tubercles over the surface with calices extending uniformly over the tubercles."—James, *loc. cit.*

The internal structure of this species is thus described by Nicholson (Genus Monticulipora, p. 182):

"Tangential sections show that the corallites are uniformly thin-walled and polygonal, slight nodes being often formed at the angles of junction of contiguous tubes. Their size is very uniform, though groups of corallites of slightly larger dimensions than the rest are certainly occasionally developed. In any case, there exists no series of small interstitial tubes. Vertical sections show that there is no difference whatever in structure between any one set of corallites and any other. In none are the walls thickened towards the surface, but they are uniformly thin throughout, and are often slightly wavy. The course of the tubes is straight, there being no curvature near their bases, and they increase in number in passing outwards by the interpolation of fresh tubes. In a great number of the tubes no tabulae exist at all; but an occasional tabula is sometimes developed near the mouth of the tube, or at some depth below the surface."

1.34C14a, B1-3.

LEPTOTRYPA DISCOIDEA (Nicholson).

Plate XX, figs. 2-2f.

Chaetetes discoideus Nicholson, 1874, Quar. Jour. Geol. Soc. London, XXX, p. 511, pl. xxx, figs. 4-4d. (Named, but not descibed or figured, by James, 1871, Cat. Foss. Cin. Group.)

"Corallum free, discoid, plano-convex, sharp-edged, from 5 to 8 lines in diameter, and about 1 line in greatest thickness. Under surface concave, covered with a very thin, smooth, and not regularly striated epitheca, which usually exhibits two or three concentric wrinkles. In general the epitheca is so delicate as to reveal clearly through its substance the bases of the superjacent corallites. Upper surface gently convex, not exhibiting any tubercles or elevations of any kind. Corallites subequal; calices with moderately thin walls, polygonal, from eight to ten in the space of one line. No groups of larger-sized corallites, nor any very minute intermediate tubuli.

"I do not feel altogether certain that this form is distinct from the young of *Chaetetes petropolitanus*. It is, however, a common form, and is very constant in its dimensions. Apart from its discoidal plano-convex form, it is distinguished by its great tenuity (comparatively speaking), the sharp thin edges of the disk, the absence of surface-tuberosities or groups of large-sized corallites, and the extreme thinness of the epitheca, which is transparent and is not regularly striated concentrically. But for one character, I should have been disposed to have placed this species under

Chaetetes (*Nebulipora*) *lens,* McCoy; and that is the absence in our examples of any groups of large-sized corallites, whereas their presence is a marked feature in the latter. The under side of *C. discoideus* resembles *Lichenalia calycula,* James; but it may be distinguished by the absence of radiating striae, and by other characters as well. The above description of the species is drawn from type specimens forwarded to me by Mr. U. P. James."—Nicholson, *loc. cit.*

Comparison with *Chetetes petropolitanus* is now unnecessary, owing to the fact that that name is known to stand for so much confusion in the matter of identifications by various authors as to be practically meaningless. The external characters of the present species are very well described above, and the internal characters are sufficiently well illustrated in the plate accompanying this report (after Nicholson, Genus Monticulipora) to make further description unnecessary.

1.34C14a. (?)

MONOTRYPELLA AEQUALIS Ulrich.

Plate XX, figs. 4-4c.

Monotrypella aequalis Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V. p. 247, pl. xi, figs. 3-3a.

"Zoarium somewhat irregularly ramose, the branches cylindrical or compressed, and from two to five-tenths of an inch in diameter. Surface, often, smooth, usually however exhibiting low, rounded monticules, which are occupied by clusters of large cells, the diameter of which does not exceed 1/55th of an inch. The ordinary cells are thin-walled and polygonal in shape, with an average diameter of about 1/90th of an inch. Occasionally a few cell-apertures, having a slightly smaller diameter than the ordinary cells, may be observed among the large cells occupying the monticules. The latter are arranged at distances apart of about .15 inch, measuring from center to center.

"In tangential sections the tubes are regularly polygonal, with moderately thickened walls, and in contact with each other on all sides. The line of demarkation between contiguous tubes is sometimes clear and distinct, while at other times it is scarcely detectable. The walls are occasionally thickened at the angles of junction of the tubes, giving somewhat the appearance of spiniform tubuli. It is quite evident though that these nodal thickenings are not of this nature.

"Longitudinal sections show that the tabulation of the larger tubes composing the clusters observed at the surface, is not different from that of the ordinary tubes, the diaphragms in all the tubes being straight and usually horizontal, in the axial region either wanting or remote, and in the peripheral portion of the branch, closely set, and often crowded. These sections also show that true interstitial tubes are entirely absent.

"In transverse sections the tubes in the axial region are subequal and polygonal, with very thin walls, while around the margin, where the tubes are cut longitudinally, they have the same appearance as in the peripheral portion of a vertical section.

"This species is nearly allied to the European *M. pulchella,* E. and H., a Wenlock Limestone species, from which it differs principally in having more numerous diaphragms, and the line of demarkation between adjoining tubes less strongly marked."—Ulrich, *loc. cit.*

The anomalous or exceptional nature of this species, the genotype of *Monotrypella* is mentioned under the diagnosis of that genus. The specimen of which I give a tangential section seems to be devoid of acanthopores and to possess the internal characters of the present species. My specimen also comes from about the same general horizon. Possibly some of the specimens referred by me to this species will be found to contain acanthopores and consequently to be referable to some other species.

1.34Co, 5, 6, 8.

MONTICULIPORA EPIDERMATA Ulrich and Bassler.

Plate XX, figs. 5-5c; Plate XXX, fig. 12.

Monticulipora epidermata Ulrich and Bassler, 1904, Smithsonian Miscellaneous Collections, XLVII, p. 17. (Not figured.)

"This species is so abundant and characteristic of the middle Richmond of Ohio and Indiana and also so easily recognized by the external characters which are clearly shown in Quenstedt's figures (loc. cit.) that we think it desirable to describe its internal characters. Unfortunately these cannot be illustrated at this time. As the species is distinct from *M. mammulata* and marks a different stratigraphic horizon, the above new name is proposed for its future designation.

"*M. epidermata* is readily distinguished from *M. mammulata,* with which it has generally been identified by collectors, by differences in their respective methods of growth. Both are massive species [sic], but the Richmond form grows into large flat or irregularly hemispherical masses, sometimes as much as 300 mm. in width and 150 mm. in height, and always, in the hundreds of specimens seen by us, having a more or less flattened though strongly undulated epithecated base. *M. mammulata* never attains such large proportions, and its masses are irregularly lobate or more or less rounded, instead of depressed hemispheric. Another distinction lies in the mesopores, which are more numerous in *M. epidermata*. The following description sums up the characters of this new species.

"Zoarium of broad, thick, lamellate expansions or masses, sometimes reaching the dimensions mentioned above. Base always lined with an epitheca and more or less flattened and concentrically wrinkled. Surface with rather closely arranged maculae, which sometimes form sharp tubercles and again rounded monticules. Zooecia small, rather thin-walled, angular where mesopores are less common and rounded where they are abundant; 10 to 11 zooecia in 2 mm.

"In tangential sections the zooecial walls exhibit the usual granulose structure characteristic of the genus. Acanthopores small, rather inconspicuous, appearing more like granules. The mesopores are small, 2 to 3 usually to each zooecium. Vertical sections show the mesopores tabulated with straight diaphragms one-half to one tube-diameter apart. Cystiphragms line the zooecial tubes in both regions and are accompanied by a corresponding number of diaphragms."—Ulrich and Bassler, *loc. cit.*

In July, 1907, the writer received Tome II, Fascicule II of the Annales de Paleontologie, in which on page 18 (90) are figured thin sections of the type of *Monticulipora filiasa* d'Orbigny, which may prove to be the above described species. The sections figured in the Annales are certainly to my mind much more suggestive of *M. epidermata* than of *Prasopora falesi* (James), with which the writer in the Annales, A. Thevinin, seems to think it should be identified. His figures leave something to be desired, inasmuch as it is not possible from them to determine whether the zooecial walls have the granulose structure of the genus *Monticulipora* or the well defined acanthopores of *Prasopora*. This question will be further discussed under *Amplexopora filiasa*.

This well-defined species of *Monticulipora* is very abundant in the Whitewater division of the Richmond, which might very well be called the *M. epidermata* zone. I have, however, found it sparingly outside of Richmond, in Indiana. It occurs at Weisburg (one specimen from the base of the Whitewater) and at Versailles (in the Whitewater ?) and more abundantly about Laurel (also in the Whitewater ?). These specimens from southern localities are all small, but their internal structure leaves no doubt of their complete identity with the above species. They afford very interesting evidence bearing on the stratigraphy of the upper members of the Richmond series, as is pointed out elsewhere in this report.

1.34A19-21....1.41A6, 7, 8, D3, E2, 3, 4, 5, 6, 7....1.60H11, and at the localities named above.

MONTICULIPORA MAMMULATA d'Orbigny.

Plate XXI, figs. 1-1c; Plate XXXI, figs. 1, 1a.

Monticulipora mammulata d'Orbigny, 1850, Prodrome de Paleontologie, I, p. 25.

"*374. mammulata, d'Orb., 1848. *Ceriopora mammulata,* Readle (envoye sous ce nom). Espèce en lame dont les monticules sont allongés. Etats-Unis, Cincinnati, Ohio (Blue Lime)."—d'Orbigny, *loc. cit.*

Since the above description by d'Orbigny might apply to any one of a large number of frondescent bryozoa of the Cincinnati group, I quote here the very full description of this form given by Ulrich in the Journal of the Cincinnati Society of Natural History, vol. V, p. 234 (1882).

"Zoarium occurring as irregularly lobate masses, often of considerable size, that usually tend to throw off compressed processes, which in many specimens become frondescent; or, it may take the form of extended and undulated, often palmate, expansions, varying in thickness from 2 inch [.2 inch?] to .4 or .5 inch. Surface covered with numerous prominent, typically conical, often elongated monticules. The last feature is produced by the fusion of two or three of them. They are quite regularly arranged in series, in which sometimes five, usually, however, six, may be counted in the space of .5 inch. Cells polygonal, thin-walled, subequal, from 1/120th to 1/130th inch in diameter, those occupying the summits of the monticules being scarcely larger than those in the intervening spaces. Smaller or interstitial (?) cells may occasionally be observed, more frequently on the monticules where they are wedged in between the ordinary cells. When the cell-walls are perfectly preserved, they show the spiniform tubuli as minute granules.

"Longitudinal sections show conclusively that the zoarium is divided into successive 'immature' and 'mature' zones. In the first, the cell-walls are very thin, and the tubes are almost invariably crossed only by straight or somewhat obliquely directed diaphragms, at distances apart of about one tube-diameter. This zone is very narrow, and soon a 'mature' zone is entered, when the walls are slightly thickened, the diaphragms more crowded, and the greater number of the ordinary tubes have along one or both sides a series of cystoid diaphragms; now there is also developed a limited number of much smaller tubes, which differ, at least near their point of origin, from the ordinary tubes in having more closely arranged diaphragms. In consequence, they have there the usual appearance of interstitial tubes. This character they may retain throughout the zone, but as they enter the next succeeding 'immature' zone, their character has changed to that of an ordinary tube. The spiniform tubuli can not often be detected in a section of this kind.

"A tangential or rather transverse section may present three different phases, according as it may pass either through the 'immature' (1st), or fully 'mature' (3d) stage; or (the 2d) if it cut the tubes just as they enter into the last stage. In the first, the tubes have excessively thin walls, and are always apparently of one kind only, and thoroughly simple. In the second the walls are still very thin, and the appearance is like that of the preceding stage, excepting that we now observe quite a large number of smaller cells, wedged in among the ordinary tubes. In the third stage, the walls have become appreciably thickened, the smaller tubes, noticed in the second stage, have all, excepting a few among the cells occupying the monticules, changed their character, so that they can no longer be distinguished from the ordinary cells. This stage is further marked by the development of a large number of very small spiniform tubuli. Of the different phases above described, a single section may show only one, or, if large, all three.

"The normal mode of growth of *M. mammulata* is unquestionably the same as in other massive or discoidal forms of the *Monticuliporidae*. The frondescent examples of the species have an entirely different structure from such truly frondescent forms as *Heterotrypa frondosa*, D'Orb. (not Nicholson), or *Homotrypa dawsoni* (*M.* (*Heterotrypa*) *dawsoni*, Nicholson). In the latter, as well as in all the ramose species, the frond or branch is divided into an axial and a peripheral region, and the structure of the tubes in these two regions, as is shown on page 125 of this JOUR-

NAL, is widely different. No such difference can be shown to exist between the axial and peripheral portions of any frondescent specimen of *M. mammulata*. What we do find is precisely similar to the structure and mode of growth observed in the massive or lobate examples of the species, viz.: the 'immature' and 'mature' zones (respectively equivalent to the axial and peripheral regions of the ramose and truly frondescent forms), are reproduced at successive levels, one above the other, and it can not be said that the fronds are ever divided into dissimilar axial and peripheral regions.

"Dr. Nicholson, in his description of this species, under the name of *Monticulipora* (*Peronopora*) *molesta* (see syn. above), fails to recognize several important characters, and besides gives an incorrect measurement. He gives the diameter of the cells as from 1/80th to 1/90th inch. I have not seen any specimen of this species in which the ordinary cells had a greater diameter than 1/120th of an inch, nor do the cells in his tangential sections, as figured by him, appear to have a greater diameter. At any rate, it is certain that the cells in that figure are not so large as those figured of some other species, which, according to the measurements given by him, ought to be smaller. He did not recognize the nature of the interstitial (?) tubes, but regards them as true interstitial tubes, and of the same nature as in *Peronopora decipiens*, Rominger, and *Heterotrypa frondosa*, D'Orb.; but as I have above stated, this is not their true nature. His tangential section cuts the tubes transversely through the 2d phase mentioned by me in my description of the tangential section of this species, and because it shows a larger number of the intercalated small tubes, I believe that it was prepared from one of the frondescent examples, tangential sections of which always present a greater number of the small tubes than do transverse sections of the massive specimens. This I consider due to the fact that in the frondescent forms the divergence of the tubes is much greater than in the massive examples, making it necessary that the young cells be more numerously and rapidly developed in the former than in the latter.

"I would suggest and recommend that Nicholson's name *molesta* be retained as a varietal designation for the frondescent examples of this species, as some title, by means of which it may be distinguished from the massive and lobate examples, is, if not really necessary, at least desirable."—Ulrich, *loc. cit.*

All possible doubts as to whether this form is really the *Monticulipora mammulata* of d'Orbigny have been finally removed by the publication in the Annales de Paleontologie of a photograph of a thin section of the type in the collection of d'Orbigny (loc. cit., Tome I, pl. ix, fig. 1). The type as figured on the preceding plate, fig. 10, of that work, is the ramose form to which, according to Ulrich's suggestion, we should apply the varietal name *molesta.* In view of this last fact it would seem to be best to either discard the name *molesta* or apply it rather to the massive form. In the present report I have not distinguished between the two forms, so that both the frondescent and massive forms are included in the following citation of localities.

1.33A3....1.34B1-3....1.38Ba-h....1.34C14, and generally in the upper part of the *Platystrophia* zone.

MONTICULIPORA PARASITICA Ulrich.

Plate XXI, figs. 2-2b; Plate XXXI, fig. 2.

Monticulipora parasitica Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 238, pl. x, figs. 3, 3a.

"Zoarium usually attached to *Streptelasma* (*corniculum?*); the layers according to age, may vary in thickness from excessively thin to nearly .1 inch. The surface of the *Streptelasma* often carries a number of these parasitic patches, which, as they increase their diameter by lateral development, at last join each other. The line of junction is always marked by a slightly elevated, calcareous ridge. Not infrequently one proves the strongest, and gradually grows over the other colonies. Regularly arranged in decussating aeries, and at distances apart of about .1 inch, the surface presents small conical monticules, the summits of which usually appear to be solid, as they are occupied by minute cells; while on their slopes they carry the apertures of slightly larger cells than the average. The largest of these have a diameter of 1/85th of an inch. The spaces between the monticules are flat, and are occupied by the polygonal, and moderately thin-walled, ordinary cells, their diameter varying from 1/110th to 1/100th of an inch. Interstitial cells (if they can be so called) are developed only in the monticules, the summits of which are usually occupied by their apertures.

"Tangential sections show the tubes to be polygonal and thin-walled. Their angles of junction are usually thickened, and the small space thus formed incloses, almost invariably, a minute lucid spot. They represent in all probability very small spiniform tubuli. The appearance of the best section examined leaves me little room to doubt that the tube walls were really pierced by numerous and excessively minute foramina. Where these are not clearly shown, the wall has a peculiar granular appearance. Within the visceral chamber of each of the ordinary cells, the intersected cystoid diaphragms are shown. In a large number the cut edges of the cystoid diaphragm give the appearance of a secondary oval cell, within the polygonal walls of the tubes. Between the groups of slightly larger cells, a few thick-walled minute tubes (interstitial) may generally be observed.

"Longitudinal sections show that all the matured tubes have one or both sides lined by a series of cystoid diaphragms, while the space between the double series, or single series and opposite wall, is crossed by straight diaphragms, which are placed at distances apart of about one-third of a tube-diameter.

"I know of no associated species with which *M. parasitica* might for a moment be confounded. It is probably more nearly allied to the *M. cincinnatiensis,* Nicholson, than to any other species described from the Cincinnati group. The larger, more closely arranged, and much more prominent monticules of that species, constitute a point of difference so decided and readily apparent, that examples of the two may be distinguished at a glance."—Ulrich, *loc. cit.*

The specimen figured by me may not belong to this species, in as much as it has well developed mesopores. Its habit and superficial appearance are, however, the same as those of Ulrich's species. In its internal characters it is more like *M. cincinnatiensis* James sp. The specimen figured is from the base of the Liberty formation, near Weisburg, Indiana.

1.34A12....1.41A7, D3, E4.

NICHOLSONELLA VAUPELI Ulrich.

Plate XXI, figs. 3-3c; Plate XXXI, fig. 3.

Heterotrypa vaupeli Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., vol. VI, p. 85, pl. I, figs. 2-2b.

"Zoarium very irregular in its growth, forming twisted, and always more or less inosculated loose masses, several inches in diameter, consisting of convoluted fronds, varying in thickness from .15 inch to .3 inch. This irregularity of growth, which is very characteristic of the species, is caused by the frequent elevation of the face of a frond into a secondary frondescent growth, which eventually anastomoses with other similar divisions of the zoarium. The surface is sometimes nearly smooth, but usually is studded with small, rounded or conical monticules, the summits of which are subsolid, each being occupied by a small 'macula' of interstitial cells. The arrangement of the monticules and maculae, in conformity with that of the cells, is very regular. Measuring from center to center, seven may be counted in the space of .5 inch. The cell-apertures are circular, and regularly arranged in decussating series, which are more or less curved around the monticules. One or two rows of cells immediately surrounding each of the small 'maculae,' are conspicuously larger than the ordinary cells, their *apertures* having a diameter varying from 1-150th to 1-100th of an inch, while the diameter of the cell-apertures in the interspaces is about 1-200th of an inch. Measuring along one of the series, twelve cells may be counted in the length of .1 inch. On an example of this species the cell-interspaces are comparatively thick, and may show, according to the stage of development and state of preservation, either all, or one or two, of three different appearances. In the first (probably due to attrition), the interspaces are smooth and apparently solid. In the second, they carry numerous small pits, representing the orifices of the interstitial cells. In the third the apertures of the interstitial cells are obscured by an exceedingly large number of small spines or granules. The last phase doubtlessly represents the zoarium in its perfect and fully matured stage.

"Tangential sections, according to the depth at which the zoarium is divided, may show one or both of two distinct phases. In the first (the one usually obtained on account of the unusual brevity of the 'matured' portion of the tubes) the cells have moderately thin walls, are subangular or nearly circular, and in contact at limited points, the intervening spaces being occupied by smaller and angular interstitial cells. The spiniform tubuli, if any at all can be detected, are small and inconspicuous. In the second phase, which is obtained by cutting the cells of a fully matured specimen just below the surface, the interstitial cells appear to be almost entirely suppressed by the remarkably great developm[illegible] of spiniform tubuli, which are ranged in one or two closely-crowded series around the cell cavities. Fig. 2*a*, Pl. I [of Ulrich's paper], represents a portion of a section somewhat intermediate between the two phases described.

"Longitudinal sections show that the tubes in the axial region have very thin and somewhat flexuous walls; that they approach the surface gradually, and that the peripheral or 'mature' belt on each side of the frond is very narrow, and, as they enter the latter region, that their walls are thickened. In the proper zooecial tubes the diaphragms are usually wanting throughout the axial region, and they are never numerous even in the peripheral portion of the zoarium. In the interstitial tubes they are numerous, and generally very thick.

"In its internal structure this species is very remarkable, and differs widely from *H. frondosa.* One peculiarity in its structure I can as yet not fully understand. That the interstitial cells are actually suppressed as the zoarium becomes fully matured, I must doubt. I would rather believe that the spinform tubuli, which are developed in the spaces that in the earlier stages of the growth of the zoarium were occupied by interstitial cells, have sprung from the surface of diaphragms which covered the interstitial cells. I am upheld in this belief by finding, what appears to me to be, corroborative evidence: namely, on many diaphragms of the interstitial tubes I can detect one or two rather faintly delineated, hollow processes, extending upward from the diaphragm toward the one next succeeding. If this is not deceptive, then we have a curious analogy with such more recent bryozoa as *Heteropora pelliculata,* Waters (a recent species), in which the orifices of the interstitial cells are closed by a *perforated* pellicle. The only difference (as regards this point) between such forms and *H. vaupeli* being that in the latter the surface of the pellicle or diaphragm is elevated into a hollow spine, instead of being perforated by a simple foramen.

"Examples of *H. vaupeli* are readily distinguished from all the other frondescent *Monticuliporidae* described from the Cincinnati group, by their peculiar growth, circular cell-apertures, and regular arrangement of the cells and monticules. When in a good state of preservation the most striking characteristic is found in the granular cell-interspaces."—Ulrich, *loc. cit.*

This extremely well-marked species is common at one or two levels in the Lorraine, and I have collected a form that does not seem to be specifically distinct, from the Liberty and Whitewater divisions of the Richmond series. Nothing need be added to the above very full description.

1.33A3....1.34A11....1.41D3, E3....1.38Bb and H.

PERONOPORA PAVONIA (d'Orbigny).

Plate XXII, figs. 1-1c; Plate XXXI, figs. 4, 4a.

Ptilodictya pavonia d'Orbigny, 1850, Prodrome de Paleontologie, I, p. 22 (not figured).=*Peronopora decipiens* (Rominger), Proc. Acad. Nat. Sci. Philadelphia, 1866, p. 116.

"*369. pavonia, d'Orb., 1848. Espèce en grandes lames frondescentes souvent très-épaisses à leur base. Etats-Unis, Cincinnati, Ohio."—d'Orbigny, *loc. cit.*

Under the description of *Escharopora pavonia* (E. and H.) the fact that the type of *Ptilodictya pavonia* d'Orb. is the same species as our *Peronopora decipiens* (Rominger) is pointed out. This is made certain by the recently published figures of d'Orbigny's type.* These figures, which are very excellent photographic reproductions, show the type natural size, a portion of the surface enlarged ten diameters and a section perpendicular to the surface, also enlarged ten diameters. The form and surface characters of the specimen would convince any one that it is a *peronopora*; and no possible doubt remains after a glance at the section, which shows very clearly the median lamina and closely tabulated tubes with the series of cystiphragms, characteristic of the latter genus. It is a typical *Peronopora decipiens.* If one compares these figures of d'Orbigny's type with the figures of *Chaetetes pavonia* on pl. 19 of the Monographie des Polypiers Fossiles, of Milne-Edwards and Haime, it is at once evident that they do not represent the same species, or even the same genus. Edwards and Haime's form is quite certainly our *Escharopora pavonia,* as I have pointed out under that species. Since the two are generically distinct we are at liberty to retain the name *pavonia* for both species, and this I have thought best to do. Rominger's name, *decipiens,* must, however, now be dropped, and this species of *Peronopora* be known from now on as *P. pavonia.*

Peronopora pavonia d'Orb. has as synonyms, besides *Chaetetes decipiens* Rom., *C. frondosus* of Nicholson, Quenstedt and James. The latter was due to the mistake of Nicholson in wrongly interpreting the figure of *C. frondosus* given by Edwards and Haime.*

The characters of *Peronopora pavonia* are briefly as follows:

Zoarium laminar to submassive, in large examples usually more or less convoluted. One specimen in the collection has overspread the shell of *Rafinesquina alternata* as a large expansion from which the laminar portion of the frond arises. The frond consists

*Annales de Paleontologie, Tome I, pl. IX, 1906.

*Polypiers Fossiles, 1851, pl. XIX, fig. 5.

of two laminae, each with a well-defined epitheca, grown together back to back, so that the result is a frond celluliferous on both faces, and with a median, double, thin, wavy plate. Superficially, the zooecia are for the most part rounded, and more or less surrounded by mesopores. The latter are less abundant than in the species *P. vera,* and sometimes are comparatively few. Acanthopores are fairly abundant and of medium size, and in well preserved specimens give a distinctly spinose appearance to the surface. In tangential sections the zooecia are seen to have walls of medium thickness, without granules or tubules as in *Monticulipora* and *Homotrypa.* The mesopores are angular and sometimes completely isolate the zooecia. The latter are round, and only occasionally indented by the acanthopores. In longitudinal sections the median double lamina is clearly shown, and arising from it with a very short immature region the zooecia proceed directly to the surface. The zooecia are crossed by a number of diaphragms, which are more numerous near their inner ends. Lining one (the posterior) wall of the zooecia is a series of overlapping cystiphragms. The mesopores are crossed by closely set, straight diaphragms.

This species is rather common in the Lorraine and Richmond.

5.9A41....1.33A3....1.34A1, 3, 7, 10, 11, 12, 13, 14.... 1.34C13, 14a, 14b, B1-3, 4-5....1.41A6, B1, E1, 2, 3, 4, 6.... 1.12E3, A2....1.38Ba-h.

PERONOPORA VERA (Ulrich) Nickles.

Plate XXII, figs. 2-2b; Plate XXXI, fig. 5.

Peronopora vera Ulrich, 1888, Am. Geol., II, p. 40. (Named but not described or figured.) Nickles, 1905, Kentucky Geol. Surv., Bull. No. 5, p. 46, pl. ii, fig. 1.

In as much as the original mention of this species was not accompanied by either description or figure, the species should according to the rules of nomenclature be accredited to Nickles, who has recently described and figured it in the work indicated above. The description given by Nickles is as follows:

"Zoarium consisting of bilaminar fronds, from 2 to 6 mm. thick and 10 or more cm. in height. Fronds usually somewhat undulating and occasionally producing fronds at right angles. Some specimens branch rather frequently, others rarely. Surface smooth, except for clusters of larger cells which sometimes rise a little above the general level. Apertures circular, 7 or 8 of the ordinary size in 2 mm. Apertures in the clusters considerably larger than the others. Usually a large number of circular or subangular mesopores occupy the rather wide interspaces as well as the angles of junction. Often the center of a cluster is occupied with a large number of mesopores. In some specimens few mesopores are present. Occasionally a specimen shows a large number of small acanthopores at the surface, and these may also be seen in some sections. Zooecia have a very short immature region; in the mature region they have a linear series of overlapping cystiphragms and a few diaphragms."—Nickles, *loc. cit.*

This is the common species of the Eden formation.

5.9A6, 25, 29, 31....1.34C5, 6, 7, 11....1.37E2-4....1.38A5, 9, 17, 19, 23, 31.

PETIGOPORA ASPERULA Ulrich.

Plate XXII, figs. 3-3c.

Petigopora asperula Ulrich, Jour. Cin. Soc. Nat. Hist., VI, p. 157, pl. vi, figs. 4-4c.

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

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

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

"This species does not resemble either *P. gregaria*, or *P.*

petechialis, very closely, differing from both these species in having distinct monticules and more conspicuous spiniform tubuli. *P. petechialis* forms very small conical zoaria, never, so far as I have been able to observe, more than .12 of an inch in diameter. Its vertical range is extended, I having collected typical specimens in the Upper Trenton rocks of Kentucky, and at nearly all elevations in the Cincinnati group. The range of *P. asperula* is much less extended, being apparently restricted to the strata between 300 and 450 feet above low water mark in the Ohio river [at Cincinnati, O.]."—Ulrich, *loc. cit.*

1.33A3....B1-3, C14a.

PETIGOPORA GREGARIA Ulrich.

Plate XXII, figs. 4-4c.

Petigopora gregaria Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 155, pl. vii, figs. 3-3c.

"Zoarium consisting of small patches usually from .1 to .3 of an inch in diameter, and .04 inch in thickness, adhering to foreign bodies. Nearly all of my specimens are attached to *Heterotrypa frondosa* D'Orb. A narrow, usually smooth, but sometimes slightly wrinkled, germinating membrane forms the outer margin, which is slightly elevated, and developed in advance of the young marginal cells. Surface without monticules, and covered uniformly by the apertures of equal sized cells, twelve or thirteen of which are ranged in a series .1 of an inch in length. Interstitial cells wanting. Spiniform tubuli may be detected on well-preserved examples by viewing the cells obliquely. In all cases, however, they project so little that they are easily overlooked.

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

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

1.33A3.

PETIGOPORA PETECHIALIS (Nicholson).

Plate XXII, figs. 5, 5a.

Chaetetes petechialis Nicholson, 1875, Pal. Ohio, II, p. 213, pl. xxii, figs. 5-5a.

"Corallum incrusting, forming small circular patches, from less than half a line to a line and a half in diameter, attached by their bases parasitically to some foreign body, and more or less strongly convex above. The surface is usually smooth, but not uncommonly exhibits a single central elevation or tubercle. The calices are subcircular and subequal, with moderately thick walls, their margins not tuberculated or granulated, entirely without minute interstitial tubuli, their size very small, from fourteen to sixteen occupying the space of one line. The corallites in the center of the mass are nearly perpendicular, but they become more or less oblique toward the margins.

"It is possible that this may be a young form of some other incrusting species, such as *C. papillatus* McCoy; but I do not think this is the case. At any rate, in the absence of any specimens by which this could be connected directly with any other known form, I have thought it best to place it under a separate title, since it is not only common in its occurrence but is also very common in its size and other characters. It is distinguished by its forming very minute, circular, and convex patches, by the absence of interstitial tubules, and by the extremely small size of the calices. All the examples which I have seen are attached parasitically to the exterior of *Strophomena alternata* and different species of *Chaetetes,* and in general many colonies are found attached to the same object. I am indebted for the specimens from which the above description is drawn to the kindness of Mr. U. P. James."—Nicholson, *loc. cit.*

It is quite likely that many times minute encrusting species identified as the above, might turn out, on investigating their internal characters to be the young of other species. It is not an easy matter, however, to obtain satisfactory sections of these minute bodies, and the entire specimen is nearly always sacrificed in the operation. My identifications are for the most part based on the external appearance.

1.33A3....1.34A1, 3, 8, 9, B1-3, 4-5, C14a.

PRASOPORA HOSPITALIS (Nicholson).

Plate XXIII, figs. 1-1b; Plate XXXI, fig. 6.

Monticulipora (*Prasopora*) *Selwynii* var. *hospitalis* Nicholson, 1881, Genus Monticulipora, p. 209, fig. 45.

"The type form of *M. Selwynii* occurs in the Trenton Limestone of Canada; but there is found in the Cincinnati formation of Ohio a form which possesses a very similar internal structure, and which I propose, in the meanwhile, to separate as a distinct variety, under the name of *M. Selwynii,* var. *hospitalis,* Nich. In its habit and size, and in some of the minor points of its organization, this form differs considerably from the typical examples from the Trenton Limestone, which I have selected as the basis for the preceding specific diagnosis; but as it is clearly a very close ally of *M. Selwynii,* I prefer to regard it at present as nothing more than a very strongly marked variety.

"*M. Selwynii,* var. *hospitalis,* is invariably an attached form, all the numerous examples which I have seen being fixed to the exterior of the shells of Brachiopods. In form they are hemispheric, rarely nearly globular, and their general size is from six to ten lines in diameter, and from three to four to seven or eight lines in height. Tangential sections show a close correspondence in general structure with the type-form of *M. Selwynii,* from the Trenton Limestone. The corallum is composed of large and small corallites, the former being oval or circular in shape, and varying from 1-50th to 1-70th inch in diameter, each showing an excentrically perforated tabula. The small corallites are numerous, sub-angular, and wedged in between all the larger tubes, occasionally being aggregated into star-shaped groups or 'maculae'. Besides the normal two kinds of corallites, a considerable number of thick-walled hollow spines ('spiniform corallites') may be observed, which I have not detected as present in the examples from the Trenton Limestone.

Vertical sections show the same marked difference in the tabulation of the large and small corallites as has been previously noticed in the type-form, with some differences. The large tubes are always doubly tabulate, one set of tabulae forming a series of large lenticular vesicles, the convex sides of which are directed inwards towards the center of the visceral chambers, while the remaining tabulae are horizontal and remote, and extend from the lateral wall of the corallite to the inner margin of the above-mentioned vesicles. In some of the tubes we may occasionally notice the convex tabulae to form isolated vesicles, as they usually do in the specimens from the Trenton Limestone; but they are more commonly so apposed to one another as to form vertical rows of lenticular cells, the inner margins of which unite so as to constitute an apparent median septum to the corallite. The small corallites are uniformly furnished with numerous complete, horizontal tabulae. Upon the whole, I have little doubt that the specimens now described from the Cincinnati Group of Ohio are not specifically separable from the true *M. Selwynii* of the Trenton Limestone."—Nicholson, *loc. cit.*

The above description by Nicholson is entirely adequate. At present *P. hospitalis* is generally considered as a species distinct from *P. selwynii.* It is peculiar in being the only species of this genus in the Cincinnati group and also in the fact that it presents certain characters not found in the typical members of the genus occurring in the Trenton, namely large and abundantly developed acanthopores. In form, *P. hospitalis* is fairly typical, although rather more inclined to form irregular masses than its Trenton relatives, which are usually very regularly hemispherical or subconical in form. The specimen figured herewith is about typical of the more regular zoaria of the Richmond form. Occasionally thin crusts are found, probably the basal portion of an incompletely developed colony. On the other hand fusiform or club-shaped masses are occasionally met with.

P. hospitalis is very common in the Richmond series of rocks, and comes as near ranging throughout the series as any species that I know of. In the Waynesville, however, it is lacking except at the very top of the formation, and I am not aware of its occurrence in the Arnheim, which has lately come to be considered as a member of the Richmond series.

1.34A10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22....1.41A2, 4, 5, 6, 7, 8, 10a, B2, C1, D1, 2, 3, E1, 3, 4, 5, 6, 7....1.12E3, D1-6, F3.

PROBOSCINA AULOPOROIDES (Nicholson).

Plate XXXII, figs. 4, 4a, and 5.

Alecto auloporoides Nicholson, 1875, Pal. Ohio, II, p. 267, pl. xxv, figs. 2-2b.

"Polyzoary creeping, adnate, of narrow branches, which divide at more or less acute angles, and repeatedly inosculate, so as to give rise to a complicated network, the meshes of which are usually more or less elliptical, and have a long diameter of one line, less or more. Cells tubular, partially immersed, but free close to their apertures, sometimes uniserial, but more commonly arranged in two alternating rows, and sometimes irregularly disposed at the points of anastomosis of the branches. About six or seven cells in the space of one line. Cell apertures terminal, circular, of the same diameter as the tube, the last portion of the cell being more or less conspicuously elevated above the general surface.

"This form seems to have been usually regarded as identical with *Aulopora arachnoidea,* Hall, to which it bears a considerable superficial resemblance; but it is certainly distinct, and it seems to me to be an unequivocal *Alecto.* It is nearly allied to *A. frondosa,* James, from which it is distinguished mainly by its much more slender habit and graceful form, and by its generally having its cells arranged in a single or double series."—Nicholson, *loc. cit.*

1.33A3....1.34A10, 11, 12, C14a....1.41D3, E3, 4.

PROBOSCINA FRONDOSA (Nicholson).

Plate XXXII, figs. 3-3b.

Alecto frondosa Nicholson, 1875, Pal. Ohio, II, p. 266, pl. xxv, figs. 3-3b.

"Polyzoary creeping, adnate, of reticulating and anastomosing branches, which sometimes become more or less completely confluent, and thus give rise to a thin expanded crust, or which may be partially reticulated and partially confluent. When the branches form a network, the meshes are usually extremely variable in size and disposition, but they are in general more or less oval, and have a long diameter of from half a line to a line or more. The cells are uniserial on the narrowest branches, but biserial, triserial, or multiserial on other parts of the coenoecium; elongated and tabular, immersed below, but free toward their aperture, the terminal portion of the tube being more or less elevated above the general surface. Cells from six to eight in the space of one line. Cell-mouths terminal, circular, of the same diameter as the tube.

"There does not appear to be any reason for doubting that this is a true *Alecto.* It is nearly allied to *A. auloporoides,* especially as regards the size and form of the cells; but the greater width of the branches, and their common coalescence into crusts, together with the greater number of the rows of cells over most parts of the coenoecium, communicate to the fossil quite a peculiar appearance, and appear to be characters of specific value. The above description is drawn from type specimens kindly furnished by Mr. U. P. James. The examples that I have seen are parasitic upon the valves of *Orthis* and *Strophomena,* and upon various species of *Chaetetes.*

"I have seen one specimen, in the collection of Mr. Dyer, of Cincinnati, in which the spaces between the cells are very minutely porous or tubular, and I am informed by Mr. James that a similar specimen exists in his cabinet. It is possible these may constitute a distinct species."—Nicholson, *loc. cit.*

Further description is not necessary for the identification of this species. It is not uncommon in the Lorraine and Richmond formations.

1.33A3....1.34A12, 19-21, B1-3, C13....1.41D1, E4, 6.

PTILODICTYA PLUMARIA James.

Plate XXIV, fig. 1; Plate XXXII, fig. 6.

Ptilodictya plumaria James, 1878, The Paleontologist, No. 1, p. 4.

"Polyzoary plumose, pointed at the base, divided into three lobe-like parts by longitudinal depressions commencing near the base, which flatten out gradually as they approach the upper part, with a row of elongated, oblique pits in each depression directed outward and upward; the lower part of the central lobe gently curving from the base upward to about half the length of the specimen; the lateral lobes expand quite rapidly, and to thin edges—one side at a sharper angle than the other. On the surface are several rows of slightly radiating low nodes. Quite strong longitudinal wavy lines on the central lobe, from eight to ten in the space of a line, between which, measuring in the same direction, are about ten circular or oval cell apertures in the space of a line. The cells on the lateral lobes are quite indistinct on the only specimen yet examined, caused by weathering. A small portion of the upper part is covered with rock; the exposed part measures one and three-quarter inches in length, and seven-eighths of an inch in width at the broadest part."—James, *loc. cit.*

According to Bassler, James' type is from Warren County, Ohio. The species occurs at a number of localities in Ohio and Indiana.

1.34A17 (?)....1.41E6.

RHINIDICTYA LATA (Ulrich).

Plate XXXII, figs. 7, 7a.

Dicranopora lata Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 166, pl. vi, figs. 16, 16a.

"The segments of this species are about one inch in length; their width at the lower or simple end is about .08 inch; at the bifurcated end the width is usually about .16 inch; the greatest thickness rarely reaches .03 inch. The two articulating branchlets are remarkably short, being generally only about .05 inch; they are only indicated by a narrow cleft in the widest end of the segment. Cells with thick walls and very small oval apertures. There are about ten longitudinal rows of cells near the lower end, and at least twenty just below the bifurcation. Measured along the length of a segment eight cells occupy the space of .1 inch. There are two rows of obliquely arranged cell-apertures along each of the acute margins.

"The wide segments, thick cell-walls, and remarkably short articulating branchlets constitute the distinguishing features of the species."—Ulrich, *loc. cit.*

1.34A9.

RHINIDICTYA PARALLELA (James).

Plate XXXII, fig. 8.

Ptilodictya parallela James, 1878, The Paleontologist, No. 1, p. 5. (Not figured.)

"Polyzoary a flattened, linear, unbranched, two-edged frond, about one line wide, longest example observed one inch. Surface gently convex celluliferous on both faces; edges very thin and sharp. Eight or ten alternating rows of elliptical cells arranged between longitudinal lines; one row on each edge having an oblique direction. Cell apertures not raised, five or six in the space of a line measuring longitudinally."—James, *loc. cit.*

The above description is adequate for the recognition of the species. According to Bassler, *R. granulosa* James is the same species as *R. paralella,* the granulose individuals representing merely the more mature stages of the species.

1.34C13, 14a.

RHOMBOTRYPA CRASSIMURALIS Ulrich.

Plate XXIII, figs. 2-2c.

Monotrypella crassimuralis Ulrich, 1890, Geol. Illinois, VIII, p. 452, pl. xxxviii, figs. 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. Zooecial 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 zooecial cavities; thickest on the monticules, where a few illy defined mesopores are generally 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 zooecia; 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 the 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 obviousy 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 interzooecial spaces. This character alone readily distinguishes the species from its nearest allies."—Ulrich, *loc. cit.*

To this species I have referred a peculiar small, irregular, massive, tuberculated specimen from near the top of the Whitewater division at Richmond, Indiana. A section of this specimen is figured in this report. The external characters do not correspond to Ulrich's description, but the internal characters seem to be identical.

1.41E1.

RHOMBOTRYPA QUADRATA (Rominger).

Plate XXIII, figs. 4-4b; Plate XXV, fig. 5.

Chaetetes quadratus Rominger, 1866, Proc. Acad. Nat. Sci. Philadelphia, 1866, p. 115 (not figured).

"In the blue limestone of Madison and Richmond, Ind., a well-marked form of Chaetetes is found ln abundance, which I do not see described. I propose for it the name *Chaetetes quadratus.*

"It grows in coarse ramifications, with an even or slightly monticulose surface. Tube orifices vary in size in different specimens from one-fourth to one-third of a millimeter; those on the maculae are somewhat larger; they are contiguous, polygonal or quadrate, separated by thin walls. Intertubular cells entirely wanting.

"The quadrate tube form is particularly obvious on the terminal surface of branches, or on transverse sections. On the sides of the branches the quadrate tube form gives the surface a fanciful appearance, which I cannot better explain than by comparing it with certain decorations of watch cases, consisting of concentric circle lines crossing each other."—Rominger, *loc. cit.*

The quadrate form of the zooecia as seen especially on the growing ends of branches makes the identification of this species an easy matter. I have found considerable variation in the form of the zoarium, although there is surprisingly little in the internal characters. The zoarium varies from submassive to strictly ramose; and the surface is either smooth, which is the usual appearance, or possesses low broad monticules. In size my specimens run all the way from small cylindrical stems a few mm. in diameter to large masses several centimeters in extent. The specimen figured is a subfrondescent branching form of rather large size.

This is one of the most persistent and abundant bryozoa in the Richmond formation.

1.34A10, 11, 12, 13, 14, 15, 16, 17, 18b, 19-21, 22....1.41A4, 5, 6, 7, 8....1.41C1, D1, 2, 3, E2, 3, 4, 6, 7....1.12E3, F3.

RHOMBOTRYPA SUBQUADRATA Ulrich.

Plate XXIII, figs. 3-3b.

Monotrypella subquadrata Ulrich 1882, Jour. Cin. Soc. Nat. Hist., Vol. V, p. 249, pl. xi, figs. 4-4b.

"Zoarium ramose, the branches slender, cylindrical, and from one to nearly two-tenths of an inch in diameter. Surface smooth, without monticules or clusters of large cells. Cells usually quadrate or rhomboidal, the apertures circular or broadly elliptical, and arranged in regular, more or less curved diagonal lines; at other times the arrangement is peculiarly irregular. Their walls are moderately thick, and on an average twelve may be counted in the space of .1 inch. A few smaller cells (which sections show to be of the nature of interstitial tubes) are intercalated among the ordinary cells.

"Tangential sections show that the tubes have moderately thick walls, which preserve, more or less distinctly, the primitive boundary line between adjoining tubes. Small interstitial tubes are always shown, and although their number varies in different sections, they are never numerous.

"In longitudinal sections the tubes in the axial region of the branch have very thin walls, and diaphragms are usually wanting in this region. As they approach the surface their walls are moderately thickened, and comparatively remote horizontal diaphragms are developed (from one-half to two tube-diameters distant from each other). Occasionally the section cuts one of the interstitial tubes, in which the diaphragms are about nearly as numerous as in the ordinary tubes. The development of young tubes, by gemmation, takes place simultaneously in all the tubes at a point on a line crossing the branch at regular intervals, with a strong upward curve. Eight or nine of these intervals occur in the space of .3 inch. In transverse sections the tubes in the central portion of the branch are thin-walled and strictly quadrate or rhomboidal.

"In many respects this species closely resembles *M. quadrata,* Rominger, and might almost be regarded as a dwarfed variety of that species, were it not for the certain presence of interstitial cells in *M. subquadrata.* Another difference is found in the size of the cells, Rominger's species having from seven to eight in the space of .1 inch, while in the new species there are about twelve in the same space. Besides, *M. quadrata* is a much more robust species with branches varying in diameter from three to six-tenths of an inch.

"As before remarked, I can not at present consider the existence of interstitial tubes in *M. subquadrata,* as of more than specific importance, in so far as it has reference to the separation of the species from *M. quadrata.*"—Ulrich, *loc. cit.*

If I correctly understand the characters of this species my collections contain but a single specimen, from the base of the Liberty formation at Richmond, Indiana. I am not sure, however, but that I may have given more latitude to the common species *R. quadrata,* than the author of the above species would approve of. At a number of levels I have found small ramose forms that seemed to differ in no other respect from the typical *R. quadrata,* than in their small size and shape. Since I did not detect any mesopores in these specimens I concluded in each case to refer them to the species *quadrata.* If these small forms are to be referred to the above species, its range and distribution would be considerably extended.

RHOPALONARIA VENOSA Ulrich.

Plate XXXI, figs. 7, 7a.

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

"Polyzoary creeping, adnate, branched, and forming a very delicate network. Branches linear, with a straight central stripe or series of cells, which has two branches springing, usually from every junction of the cells, though sometimes at that of the second with the third; these branches are again divided in a similar manner, and anastomose; this peculiar mode of growth gives the polyzoary very much the appearance of the venation in a leaf. Cells uniserial, long acutely elliptical, and joined together at their contracted ends; length of the cells somewhat variable, but generally about four occupy the space of two lines. Cell mouths not clearly determined, but appear to be situated near the middle of the cell.

"This form has only been observed, incrusting *Streptelasma corniculum* [=*S. rusticum*]. On account of the great delicacy of the fossil, the fronds themselves are rarely found, but instead we find a series of impressions on the exterior coat of the *Streptelasma,* which very well represent the fronds and cells of the same."—Ulrich, *loc. cit.*

The specimen of this species figured in this report is spread over the shell of *Rafinesquina alternata.* Another specimen was obtained at Richmond, Indiana. The types are from Waynesville and Clarkesville, Ohio. According to Ulrich and Bassler it is confined to the Richmond group.

1.34A11....1.41C2-3.

SPATIOPORA MACULOSA Ulrich.

Plate XXXII, fig. 9.

Spatiopora maculosa Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 167, pl. vii, fig. 6.

"Zoarium forming large and very thin parasitic expansions, usually adhering to the shells of *Orthoceras,* but in a few instances to other objects. The surface shows at intervals of .18 inches, measuring from center to center, distinct groups of large cells, which, very rarely, however, are slightly elevated above the general level of the surface. The diameter of the cells in these clusters not infrequently exceeds 1/55th of an inch, while that of the ordinary cells averages about 1/110th of an inch. The cell-walls are moderately thin, and at many of the angles are elevated into more or less prominent spiniform tubuli, which are larger and somewhat more numerous among the cells of the clusters mentioned. The cell-apertures are more or less irregular in shape, and never, on account of the thickened wall angles, are strictly angular. Interstitial cells are entirely absent. The internal structure shows no striking peculiarities, and much resembles that of the type species.

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

To this species I have referred a specimen from the top of the hill back of Vevay, Indiana.

SPATIOPORA TUBERCULATA (Milne-Edwards and Haime).

Plate XXXII, fig. 10.

Chaetetes tuberculatus Milne-Edwards and Haime, 1851, Monographie des Polypiers Fossiles des Terrains Palaeozoiques, p. 268, pl. xix, figs. 3, 3a.

"Polypier très-mince, encroûtant. Les mamelons sont comprimés et allongés dans une même direction longitudinale, assez saillants, long de 2 ou 3 millimètres, large d'un ou d'un demi, distants entre eux de deux fois leur largeur. Le sommet des mamelons est un peu compacte. Calices peu inégaux, de forme un peu variable; ceux des mamelons pourtant un peu plus grands, et larges d'un tiers de millimètre. Cette espèce est très-voisne du *Chaetetes mammulatus;* elle paraît en différer pourtant par ses mamelons toujour plus allongés et moins saillants, et ses calices sont un peu plus grands.

"SILURIEN (inférieur). *Etats-Unis* (Blue limestone): Cincinnati, Oxford, Springfield, Lebanon (Ohio).

"SILURIEN (supérieur). *Angleterre:* Dudley.

"Coll. de Verneuil, T. W. Fletcher."—Milne-Edwards and Haime, *loc. cit.*

A free translation of the above description will suffice for its identification.

Zoarium very thin, encrusting. The monticules are narrow and elongate in the direction of the greatest length of the zoarium, quite sharp, two or three mm. long, about one or one half wide and separated from each other by about twice their breadth. The tops of the monticules are nearly solid. Zooecial apertures somewhat unequal in size, varying somewhat in form, those of the monticules rather larger, about a third of a millimetre in diameter. This species is nearly related to *Chaetetes mammulatus* from which it differs in the fact that its monticules are always more elongate and not so sharp, and the zooecial apertures are slightly larger.

This and other species of the genus are commonly found growing over the shells of Orthocerata. Nicholson has described *S. corticans,* which he afterwards considered as a synonym of the present species, and Ulrich later described *S. montifera* a species with much more conspicuous monticules. Nickles and Bassler consider Nicholson's species valid. All of these species have the elongated monticules, drawn out in a common direction. The internal characters are indicated under the diagnosis of the genus.

Reported from Indiana in Kindle's list. It occurs in the Lorraine and Richmond formations.

STIGMATELLA CLAVIS (Ulrich).

Plate XXIV, figs. 2, 2a; Plate XXV, fig. 3.

Leptotrypa clavis Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 161, pl. vi, figs. 3, 3a.

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

"Longitudinal sections show a spiniform tubulus between nearly all of the thin and straight tube-walls. Their internal cavity is distinctly shown and comparatively large. Diaphragms are usually developed at remote intervals, though often wanting. No interstitial tubes have been observed.

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

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

Ulrich and Bassler have recently placed this species in their genus *Stigmatella.*

1.34C5, 6, 7, 11.....1.33A3.

STIGMATELLA CRENULATA Ulrich and Bassler.

Plate XXIV, figs. 4-4d.

Stigmatella crenulata Ulrich and Bassler, 1904, Smithsonian Miscellaneous Collections, XLVII, p. 34, pl. ix, figs. 1-4; pl. xiv, figs. 1, 2.

"Zoarium composed of cylindrical, subcylindrical or compressed, frequently dividing stems 10 mm. or more in diameter, arising from a broad base and forming a clump probably seldom more than 50 mm. high. Surface even, but in well preserved mature specimens spinulose because of the many acanthopores. Maculae well marked, generally composed of mesopores which make up the characteristic 'spots' but sometimes formed exclusively of zooecia larger than the ordinary. Zooecial apertures small, about 9 in 2 mm. with their walls thin and often beautifully inflected by the numerous small acanthopores. Mesopores present, variable in number but usually few and mostly aggregated in the maculae. In the axial region the zooecial tubes have thin, finely crenulated walls, and occasionally a diaphragm or two. In the mature region the walls increase slightly in thickness, mesopores and acanthopores develop, and thin diaphragms cross the zooecial tubes and mes-

opores at varying though always comparatively remote intervals."
—Ulrich and Bassler, *loc. cit.*

I have one specimen of this species from the top of the Waynesville formation, near Abington, Indiana.

STIGMATELLA IRREGULARIS (Ulrich).

Plate XXV, figs. 2, 2a.

Chaetetes irregularis Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 129, pl. xii, figs. 10-10b.

"This form grows in small, free, and exceedingly irregular, masses, having a diameter varying from less than three lines to fifteen lines. Surface rarely nearly smooth, but is generally irregularly and strongly nodulated. Apertures of tubes polygonal, nearly equal in size, from eight to ten occupying the space of one line; walls of tubes comparatively thin. Interstitial tubuli are entirely absent.

"Longitudinal sections of this species have a peculiar and unique appearance. The tubes are seen to radiate from various centers, which correspond in number to that of the prominent nodules observed on the surface. Transparent sections were taken from many specimens, but no tabulae were observed crossing any of the tubes. When the tubes are cut transversely they are seen to be thin-walled and polygonal, with sometimes a small or young tube interpolated. The calcite filling the tubes is of darker and lighter shades, giving sections a peculiar appearance, and when the ends of the tubes are observed, it is divided by quite regular but faint cruciform lines, as in *C. quadratus* and several other forms.

"This species is allied to *C. lycopodites,* but is easily distinguished by its peculiar growth, and in having no diaphragms crossing the tubes. It is also related to *C. subglobosus,* but that species differs in having a more regular form, larger calices, and flexuous or wrinkled tube-walls. *C. irregularis* marks a horizon of about five hundred and fifty feet above low water mark in the Ohio river at Cincinnati, and is nearly always found where that elevation is exposed."—Ulrich, *loc. cit.*

Ulrich and Bassler have recently placed this species in their new genus *Stigmatella.* I am not sure that I have seen any specimen in Indiana. It is listed in Kindle's list of Indiana fossils, though from the locality given (Hamilton County) I am sure that either he or his authority is in error. Probably Hamilton County, Ohio, is meant. I have included it, however, because it is most likely to be found within this State.

STIGMATELLA PERSONATA Ulrich and Bassler.

Plate XXIV, figs. 3-3d.

Stigmatella personata Ulrich and Bassler, Smithsonian Miscellaneous Collections, XLVII, p. 35, pl. xii, figs. 1-3.

"This is one of the non-mesopored species of the genus and forms smooth, branching zoaria very much like *S. crenulata* and *S. spinosa*. From the former it is distinguished by having fewer acanthopores, no mesopores, and in lacking the crenulation of the walls in the immature region. From *S. spinosa* it is separated by its larger zooecia, 7 to 8 being found in 2 mm. while 10 are required in that species to cover an equal distance. The acanthopores in *S. personata* also afford a difference, being but seldom more numerous than the junction angles which they usually occupy. In *S. spinosa,* it will be remembered, they are so abundant that they almost completely surround the zooecium."—Ulrich and Bassler, *loc. cit.*

The only specimen of this species seen by me comes from near the top of the Richmond series on Elkhorn Creek, near Richmond, Indiana.

STIGMATELLA SPINOSA Ulrich and Bassler.

Plate XXV, figs. 1-1d.

Stigmatella spinosa Ulrich and Bassler, 1904, Smithsonian Miscellaneous Collections, XLVII, p. 34, pl. ix, figs. 5-8.

"The method of growth in this species is similar to that obtaining in *S. crenulata,* but under a lens *S. spinosa* is distinguished at once by having no mesopores and so many small acanthopores indenting the zooecial walls that the surface appears granulose rather than spinose, which term applies better in other species of the genus. Continuing the comparison with *S. crenulata,* the zooecia are found to be a little smaller, about 10 occurring in 2.0 mm., and the axial portion of the tube walls straighter.

"Thin sections of this species are both beautiful and instructive. In vertical sections the periodic development of the acanthopores, which is a feature of the genus, is shown especially well. Diaphragms few and of irregular distribution."—Ulrich and Bassler, *loc. cit.*

This form is reported by Ulrich and Bassler as occurring in the Richmond formation at Versailles, Indiana.

STOMATOPORA ARACHNOIDEA (Hall).

Plate XXXII, figs. 2-2c.

Aulopora arachnoidea Hall, 1847, Pal. New York, I, p. 76, pl. xxvi, figs. 6 a-c; and fig. in foot note, p. 76.

"Coral consisting of a fine weblike expansion, diffusely branching and anastomosing, attached to the surface of other bodies; tubes narrow, slender, short, subclavate or straight, single; mouth slightly elevated, opening obliquely upwards, smaller than the cell below.

"This very delicate species, in some portions of its extent, bears considerable resemblance to *Alecto dichotoma* of the Jura limestone (LAMOROUX, *Exp.*, p. 84, t. 81, f. 12-14; BLAINVILLE, *Man. d'Act.*, p. 464, t. 65, f. 1; *Aulopora dichotoma,* GOLDFUSS, *Petrefaeta,* pag. 218, pl. 65, fig. 2); but other portions develop a structure scarcely compatible with this genus, and I have therefore placed it under the Genus AULOPORA. The illustration below presents a magnified view of a distinct part from that shown on the plate, and exhibits the essential characters of AULOPORA. It is the only species of the genus known to me in the lower term of our system, and on this account is more interesting as showing the early commencement of this peculiar form of coral, which is known only in a fossil state. The lowest position in which it has been known previously, is in the Wenlock limestone, and the upper limestone of the Caradoc (Silurian System, p. 676); others occur in the Eifel (Devonian), and other species are known in the Oolite and Jura limestones.

"This is not a common fossil in the Trenton limestone, though it has been seen in several localities widely separated, thus proving its great geographical range."—Hall, *loc. cit.*

The reference of this delicate species to the coral genus *Aulopora* is of course no longer permissible. Whether it should be associated with such forms as *Stomatopora inflata,* etc., in the genus *Stomatopora,* is a question that can not be adequately discussed at this point. I have taken occasion to call attention to the unsatisfactory condition of the genus *Stomatopora* and its related genera in the diagnoses of those genera. *S. arachnoidea* has the zooecia immersed, in this respect more nearly resembling the two associated species of *Proboscina* than the other species of *Stomatopora* such as *S. inflata.* To me the uniserial arrangement, or otherwise, does not seem to be a character of generic importance, and as I have remarked elsewhere in this report, the genera will ultimately have to rest on characters of higher phylogenetic importance.

S. arachnoidea is a widely distributed and extensively ranging form, being found in the Utica, Lorraine and Richmond.

5.9A31....1.34B1-3, C9, 13....1.41B1....1.12A2, D1-6.

STOMATOPORA INFLATA (Hall).

Plate XXXII, figs. 1, 1a.

Alecto inflata Hall, 1847, Pal. New York, I, p. 77, pl. xxvi, figs. 7 a-b.

"Coral attached, arachnoid; tubes short, much expanded above, contracting at the aperture, and narrowing rapidly below; mouths large, opening obliquely upwards.

"This coral resembles the last in its mode of growth and general appearance; but the tubes are more expanded or vesicular above, and the little mouths are proportionally more distinct. It is clearly referrible to the Genus ALECTO, in its mode of growth, form, and arrangement of cells, which proceed one from the other, each base being a little below the aperture of the previous one."—Hall, *loc. cit.*

This species is commonly seen growing over the shell of *Rafinesquina alternata,* or over other bryozoa, and in the Richmond formation on the *Streptelasma rusticum.* It is a very delicate form, but from the uniserial arrangement of the zooecia and their peculiar swollen form it is easily distinguished.

1.33A3....1.12A2....1.41A7, D3, E2, 3.

BRACHIOPODA.

DIAGNOSES OF GENERA.

CATAZYGA Hall and Clarke.

Shells rather large, subcircular or ovoid; valves more convex than in Zygospira. A low median sinus in both valves; surface with a great number of fine radiating striae. Muscular impressions of pedicle valve well defined, pedicle cavity deep, with a deeply excavated, short, sharply defined longitudinally striated impression in front of it. In the brachial valve is a broad anterior and narrow, elongate, posterior pair of scars. Spirals essentially the same as in *Zygospira,* but with the apices of the cones converging toward the median line in a plane just below the surface of the brachial valve. Jugum persistently posterior in its position, originating as in *Atrypa,* the lateral lamellae bending downward toward the bottom of the brachial valve and directed forward in lines that are parallel for a short distance. Thence they bend inward and upward, meeting in a short angle in the space just behind the apices of the spirals. (Hall and Clarke.)

CRANIA Retzius.

Shell inequivalve, inarticulated, without perforation for a pedicle; subcircular in outline, generally somewhat transverse across the posterior margin; attached by the apex or the entire surface of the lower valve. Ventral valve depressed—conical or conforming to the surface of attachment. Dorsal valve more or less conical with a subcentral, posteriorly directed apex. Surface of the valves usually smooth, sometimes spinose or with concentric or radiating striae. In the interior of both valves are two pairs of large adductor scars, the posterior of which are close upon the margin and widely separated, the anterior near the center of the shell and close together, more approximate in the lower than in the upper valve. These posterior scars are often strongly elevated on a central callosity which surrounds their broad and thickened margins. Impressions of the pallial genital canals anterior. The margin of the lower valve is usually coarsely digitate. Shell substance calcareous, strongly punctate. (Hall and Clarke.)

DALMANELLA Hall and Clarke.

Shells plano-convex or subequally biconvex. Pedicle valve usually the deeper, often gibbous, elevated at the umbo and arched over the cardinal area. Hinge line generally shorter than the greatest width of the shell. Often a more or less conspicuous undefined median fold and sinus on the pedicle and brachial valves respectively. Surface with fine rounded bifurcating radiating striæ. Teeth in the pedicle valve quite prominent, thickened at their extremities and supported by lamellae which are produced forward surrounding a rather short suboval or subquadrate muscular area. Cardinal process in the brachial valve extends forward to the bases of the crural plates where it is broadened and continued thence as a median ridge separating the muscular impressions. The inner surface of this process is divided by a faint median furrow which produces two lobes at the posterior extremity, and each of these lobes is again divided making the process quadrifid. In some cases the two median divisions coalesce, making the process appear trifid. In some species at maturity and in others from abnormal growth this process becomes a broad plug which fills the entire delthyrial opening. Dental sockets small; crural plates often greatly elevated, especially in the plano-convex species, usually ending abruptly. Muscular impressions quadruplicate, sometimes with radiating ridges extending from the lateral and anterior margins. (Hall and Clarke.)

DINORTHIS Hall and Clarke.

Relative convexity of the valves reversed (*i. e.* the dorsal valve the most convex). Surface with strong rarely bifurcating plications. Delthyrium sometimes partially closed. Muscular area in pedicle valve subquadrate, bounded by extensions of the dental lamellae. In the brachial valve the muscular impressions are obscure; cardinal process erect, broad and frequently bilobed on its posterior face. Shell structure impunctate. (Hall and Clarke.)

HEBERTELLA Hall and Clarke.

Shells with convexity of the valves reversed. Surface covered with numerous fine, rounded, closely crowded plications, crossed by lamellose growth lines. Teeth in the pedicle valve large and supported by thick lamellae which are continued as a strong ridge around a short obcordate muscular area. This area is medially divived by a prominent ridge upon the summit of which lies the linear scar of the adductors. The flabellate lateral impressions are sometimes divisible into their two components, diductors and adjustors, and in old individuals the impression of the pedicle muscle is often distinct. Dental sockets in the brachial valve narrow and inclosed beneath, and on the inner side by the strong crural plates. Cardinal process elongate and simple, sometimes thickened, often crenulate, but not lobed at its posterior extremity. The process unites with the inner bases of the crural plates and is produced forward as a median ridge dividing the four muscular scars, which are distinctly developed only in old shells. Shell structure fibrous impunctate, the plications of the surface sometimes tubulose. (Hall and Clarke.)

In some of the later species of this genus the shell is coarsely punctate.

LEPTAENA Dalman.

Redefined by Hall and Clarke.

Shells plano-convex when young, concavo-convex at maturity. Surface with conspicuous concentric wrinkles over the flatter portions of the valves. Where these cease the valve is often more or less abruptly deflected. Whole exterior covered with fine radiating, thread-like striae, crenulated, in well preserved specimens, with fine concentric lines. Outline transversely subquadrate or semioval. Hinge line straight, making the greatest breadth of the shell; extremities often sub-auriculate. Cardinal area narrow, slightly wider on the pedicle valve, not denticulate. Delthyrium in the pedicle valve covered by a convex deltidium, perforated at the apex by a foramen which is closed at maturity or encroaches upon the apex of the valve. Deltidium most conspicuous in the early stages of growth. Teeth very divergent and quite conspicuous, generally supported by lamellae which are continued around the subcircular muscular area of the narrow umbonal cavity. The muscular scars consist of a narrow median or adductor, inclosed by flabelliform diductors. In the brachial valve the area is linear, the delthyrium is progressively filled by the growth of a callosity, which is often deeply grooved along the center and sometimes perforated in the line of division between the branches of the cardinal process. Cardinal process consists of two sessile diverging apophyses which have broad, flat, striated surfaces of attachment, and are extended beyond the hinge line. The sockets are moderately deep; crural plates usually not sharply defined, but are continued in a curving line along the inner surface of the valve, partially embracing a pair of broad, ovate muscular impressions which are marked by arborescent ramifications; recurving and again incurving, these ridges partially surround a pair of smaller muscular areas, lying in front of the first. Posterior pair of muscular impressions divided by a ridge which originates at the cardinal process. Second pair of impressions separated by a low slender median septum which is a continuation of the interrupted posterior ridge. The muscular area is divided into the following scars: a large posterior pair (posterior adductors) the surface of which is covered with arborescent ridges; an anterior pair (anterior adductors) close together at about the center of the valves; an elongate narrow median scar apparently divided throughout its length by a faint ridge. At the line of geniculation, the interior surface is frequently elevated into a very prominent, sharp, or abruptly rounded crest. Spiral callosities for the support of the brachia have been observed. (Hall and Clarke.)

LEPTOBOLUS Hall.

Shells small, fragile, subovate in outline; shell substance semiphosphatic. Exterior with concentric growth-lines. Interior of the pedicle valve with a notably large cardinal area, which is sharply grooved. Beneath this area is a broad depression extending nearly across the shell and divided by a low median ridge, which bifurcates at its extremity, leaving between its branches a small central muscular impression. This impression is bounded on its sides by a crescentic muscular fulcrum, which extends parallel with the margins to the anterior portion of the shell. At a point back of their centers each gives off a transverse branch extending inward and backward. In the brachial valve the cardinal area is also well developed and distinctly grooved. The limits of the muscular scars are indicated by three septal ridges, one axial and one on either side. All these ridges are bifurcated at their anterior extremities. (Hall and Clarke.)

LINGULA Bruguiere.

Shell sub-equivalve; elongate-ovate, subquadrate or subtrigonal in outline; slightly gaping at both extremities; brachial valve somewhat shorter and with a slightly thickened hinge-line. Surface smooth, or concentrically and radially striated. Pedicle long, protruding from between the beaks of the two valves. Pedicle valve with a distinct cardinal shelf or area, divided by a depression widening from the apex anteriorly (the "deltidium"). Deltidium bounded at the sides by elevated ridges, which at the anterior ends are each developed into a small callosity. Muscular impressions numerous, but usually distinct. In recent species there are twelve upon each valve. These are: the *umbonal,* near the beaks; the *lateral,* produced by three pairs of muscles; the *anteriors;* the *middles;* the *externals;* the *centrals* and the *transmedians.* The muscular region in each valve is surrounded by the *parietal bands* which leave more or less distinct impressions on the shell. The anterior internal surface of each valve bears traces of two strong pallial sinuses, which nearly meet in the axial line before reaching the anterior margin. In front of and behind these are radiating vascular markings. Shell substance composed of alternating lamellae of chitinous and calcareous material. (Hall and Clarke.)

LINGULASMA Ulrich.

Shells large, subquadrate, linguliform, sub-equivalve; brachial valve considerably the deeper. Beaks apical, cardinal margins gently sloping to the sides. Surface with concentric or radiating lines and bead-like granules. Shell substance thick, largely calcareous. Interior of pedicle valve with low, concave platform which extends over one-half the length of the shell, and is not hollowed on its anterior wall. Pedicle area largely inclosed within the shell, making a distinct sheath or shelf, beneath which lie the apical portions of the central and lateral muscular scars. Crescentic scars scarcely defined. Brachial valve deep, with high platform of about the same extent as that on the other valve, sloping inward near its anterior margin and continued axially into a strong septum which reaches nearly to the front of the valve. Anterior walls of the platform broadly excavated, and close against the base of the septum hollowed out into short conical cavities. Crescent strongly developed, sharply pointed backward at its center. Its lateral curves are broad, reaching to the edge of the platform. Directly in front of its central angle lies a short, sharp, median ridge, which disappears near the center of the platform. Lateral and central muscular scars well developed. (Hall and Clarke.)

PLATYSTROPHIA King.

Contour spiriferoid; hinge line and area long and straight, nearly equally developed on the two valves. Both valves very convex, the brachial being the more so, and bearing a very strong median fold corresponding to a deep sinus on the opposite valve. Surface marked with strong, usually sharp, radial plications, a variable number of which are on the fold and sinus. External surface, when well preserved, finely granulose. Delthyrium open in both valves, somewhat larger in the pedicle valve, and in old and very gibbous shells it has often encroached upon the umbonal region of the valve. Teeth thick and very prominent; muscular area comparatively small, and often, in old shells, deeply excavated in the substance of the shell. Not readily divisible into component scars. The cardinal process of the brachial valve is a simple linear ridge, always small and sometimes nearly obsolete. Dental sockets comparatively small; crural plates large and thick, uniting at their inner bases and produced into a prominent median ridge. Muscular area quadruplicate. Shell structure very compact and finely fibrous, without punctation. (Hall and Clarke. Cumings.)

PLECTAMBONITES Pander.

Redefined by Hall and Clarke.

Shells usually small, normally concavo-convex. Surface with very fine striae, often alternating in size. Hinge line making the greatest width of the shell, extremities often subauriculate. Cardinal area narrow in both valves, sometimes obscurely crenulated on the margins. Pedicle valve with a moderately broad delthyrium, which is partially closed by a convex plate, but mostly occupied by the cardinal process of the opposite valve. Apical foramen sometimes retained. Teeth prominent and supported by thickened plates, which are continued in broad outward curves for more than half the length of the valve, returning and uniting in the umbonal cavity, thus limiting two linguliform muscular scars, inclosing a more or less clearly defined adductor impression. Dental sockets in brachial valve deep, often appearing to transect the cardinal area. Cardinal process simple and erect, but by its coalescence with the short prominent crural plates the posterior face appears trilobate. The crural plates end abruptly as in *Orthothetes*; becoming thickened at about the middle of their length, giving origin to two low ridges or septa, which at first approach each other, and thence continue forward with a slight divergence, thus forming the inner boundaries of two elongate muscular scars, which are less sharply defined on their outer margins. The muscular area is rendered quadripartite by two short transverse or oblique posterior furrows. Vascular impressions radial, sometimes digitate. Shell substance fibrous, sparsely punctate. (Hall and Clarke.)

PLECTORTHIS Hall and Clarke.

Valves subequally convex, plications strong, simple or duplicate. Cardinal area of pedicle valve low. Shell substance impunctate. Muscular scars, dental lamellae, and cardinal process as in *Orthis* (s. s.). (Hall and Clarke.)

The present writer is inclined to doubt the value of this genus, in as much as the fact that the plications may be duplicate is practically the only distinction between it and the genus *Orthis* (*sensu stricto*).

RAFINESQUINA Hall and Clarke.

Shells normally concavo-convex. Surface ornamented by radiating striae, of alternating size, crossed and crenulated by finer concentric striae. Cardinal margins without denticulations. Interior of the pedicle valve with the muscular area not strongly limited; consisting of two broad flabellate diductor scars enclosing an elongate, more distinctly defined adductor. The faintness of the limitation of this area is in marked contrast to the sharply defined muscular area in the corresponding valve of *Leptaena*. In the brachial valve the cardinal process is more closely sessile than in *Leptaena*, and there is frequently a linear callosity between the branches. The posterior adductor scars have the arborescent markings of *Leptaena rhomboidalis*, and these impressions are the only ones well defined, the anterior scars being narrow and rarely retained with distinctness. From the anterior margin of the muscular area radiates a series of irregular furrows and nodose ridges, which are to some extent of vascular origin. (Hall and Clarke.)

RHYNCHOTREMA Hall.

Shells large, thick, often gibbous. Deltidial plates in adult shells of great size, thickened and coalesced with the bottom of the valve, their outer surface being concave. The pedicle passage encroaches upon the substance of the valve, the foramen lying behind the apex and the passage itself inclosed by the thickened deltarium. The teeth rest upon the thickened lateral walls of the valve, and there appears to have been no development of dental lamellae, unless at a very early period in the life of the shell. Median septum in the brachial valve thickened and extending more than one-half the length of the shell; the small cardinal process rests upon the posterior extremity of the septum. The bases supporting the crura are divided by a very narrow median cleft, and are remarkably broad and stout, and abruptly deflected to the deep dental sockets. The crura arise from the middle of this comparatively broad hinge-plate, instead of from the margins of the dental sockets. The muscular impressions are usually strongly developed; a deep scar of the pedicle muscle beneath the deltidial plates; the adductor impression in the pedicle valve often very marked. Adductors of the brachial and diductors of the pedicle valve more or less distinctly defined. (Hall and Clarke.)

Shell rostrate, surface covered with strong angular radiating plications; a well defined fold on the dorsal valve and corresponding sinus in the ventral valve, a variable but always small number of plications in the fold and sinus.

SCHIZOCRANIA Hall and Whitfield.

Shells subcircular in outline, inequivalve, unarticulated. Pedicle valve flat or concave; apex subcentral. A deep triangular notch extends from just behind the beak to the margin, where its arc is about one-sixth of the periphery. The apex of this pedicle notch is occupied by a triangular transverse plate or listrium, varying in size with the age of the shell, but extending from one-fourth to one-third the length of the opening. Surface marked by concentric growth-lines. No muscular impressions visible. Brachial valve more or less convex, beak marginal. Surface radially striated. The interior bears a pair of strong posterior adductor scars, lying close together in the umbonal region, their outline is subovate, and they frequently appear to be divisible into anterior and posterior elements. In front of them at about the center of the valve, are the small and faint anterior adductor impressions. A low median ridge extends from the apex to beyond the center of the valve. Shell-substance of perlaceous calcareous laminae, the inner layers appear to be corneous. (Hall and Clarke.)

STROPHOMENA Rafinesque (de Blainville).

Restricted by Hall and Clarke.

Shells transversely subsemicircular or semielliptical. Greatest width along the hinge line. Concavo-convex; surface with fine radiating striae, which are equal or alternate in size. Pedicle valve slightly convex at the umbo but becomes rapidly concave toward the middle; apex perforated except in old age. Cardinal area conspicuous, nearly vertical, delthyrium closed by a convex deltidium. Teeth widely divergent and supported by plates which are produced into elevated ridges nearly surrounding the muscular area. Latter relatively short, subcircular in outline, deeply excavated and divided medially by a more or less distinctly defined longitudinal ridge, which is often continued over the pallial region. Brachial valve concave at the umbo, becoming strongly convex farther forward; cardinal area narrow, delthyrium rudimentary or incomplete. Dental sockets deep, continued as narrow grooves or indentations across the cardinal area. Crural plates extended laterally with a slight curve, not supported by septa; united at their inner margins to form a callosity upon which rests the short, bilobed cardinal process, which scarcely extends beyond the hinge line. The muscular surface of this process is cordate in outline and is placed at a low angle to the plane of the area. A low median ridge extends forward from the hinge plate, separating two large adductor scars, in front of which are two narrow elongate impressions. Vascular and ovarian markings frequently well defined. Shell-substance fibrous, strongly punctate. (Hall and Clarke.)

TREMATIS Sharpe.

Shell subcirclar or transversely oval in outline. Pedicle valve unevenly convex, more or less depressed over the posterior region; apex at or behind the center; directly beneath it begins the pedicle fissure, which transects the shell, vertically widening to the posterior margin with straight or outwardly curving edges. Brachial valve evenly convex, with its apex marginal and slightly projecting. Interior of pedicle valve shows a faint median furrow extending from the angle of the fissure to the apex of the shell. This groove widens at its apical termination and may represent a point of muscular attachment. Sides of the fissure often with callosities. From the apex of the valve extend radiating and branching vascular sinuses. Posterior margin of brachial valve much thickened and broadly grooved for the extrusion of the pedicle. This thickening does not form a cardinal area or shelf. Adjuster and posterior adductor scars directly beneath and in front of this thickening. These scars separated by a faint median septum, which passes forward, becoming more prominent over the tongue-shaped median elevation which separates the large central scars. These impressions are oblique and not simple, each appearing to be composed of two, or three, distinct scars, making a posterior, median and anterior pair. Posterior pair small, sometimes quite sharply defined; central pair much larger, anterior pair narrow. Entire impression deeply excavated. Surface of both valves more or less completely covered by a beautiful ornamentation consisting of punctures or small pittings of various depth, arranged either in quincunx or in radiating rows. Shell-substance with an outer calcareous layer and inner corneous lamellae. The outer layer is coarsely punctuated by the pittings constituting the surface ornamentation. The corneous layers are impunctate. (Hall and Clarke.)

ZYGOSPIRA Hall.

Shells usually small. Outline subcircular or transversely oval. Contour subplano-convex. Surface sharply plicate. Pedicle valve with a median plicated ridge. Umbo narrow and prominent; beak acute and incurved. Foramen elongate, rarely apical, enclosed by the deltidial plates. Hinge line long and straight; cardinal extremities rounded. A distinct false area is formed by a pair of ridges diverging from the beak toward the cardinal extremities. On the interior the teeth are moderately well developed and unsupported by dental lamellae. The brachial valve is depressed convex in the umbonal region and bears a more or less conspicuous median sinus. The hinge plate consists of two broad, stout processes, diverging outwardly, grooved on their summits and separated from each other by a narrow, sharp cleft. They form both the socket walls and crural bases, and are supported by a low median ridge. Muscular impressions obscure in the typical species. Crura short and straight at their union with the primary lamellae, making a rectangular curve. The first half volution of the ribbon lies just within the margins of the valves, and the number of volutions is small. The spirals have their bases parallel to the lateral slopes of the pedicle valve and their apices directed obliquely toward the center of the opposite valve. Jugum continuous, variable in position and shape; its apex always angular and directed anteriorly. (Hall and Clarke.)

DESCRIPTION OF SPECIES.

CATAZYGA HEADI Billings.

Plate XXXIII, figs. 1-1c.

Athyris headi Billings, 1865, Paleozoic Fossils, I, p. 147, figs. 125-127.

"*Description.*—Broad oval or sub-pentagonal; both valves convex; sides and front margin occasionally somewhat straight. Ventral valve rather strongly convex, most elevated about the middle or a little above; beak closely incurved, in contact with the umbo of the dorsal valve; umbo somewhat carinated; an obscure mesial sinus which is usually so slightly impressed as to constitute only a flattening of the shell extends from the front margin to within one-third of the length from the beak, where it becomes obsolete; on each side of the sinus the shell descends with a somewhat flat slope to the sides. Dorsal valve not so convex as the ventral; often with an obscure mesial sinus.

"Surface with fine rounded radiating ridges, closely crowded together, of a nearly uniform size, from eight to ten in the width of two lines.

"Length about 10 lines; width a little less than the length.

"This species is dedicated to the late John Head, Esq., by whose unfortunate death science has sustained a grievous loss.

"*Locality and formation.*—On the south shore of the St. Lawrence opposite Three Rivers. Hudson River formation."—Billings, *loc. cit.*

Richmond formation, Madison, Indiana.

CRANIA LAELIA Hall.

Plate XXXIII, fig. 2.

Crania laelia Hall, 1866, 24th Rep. New York State Museum (advance sheets), p. 220, pl. vii, fig. 16.

"Shell small, discoid or moderately convex on the upper valve, somewhat narrowed towards the cardinal border. Apex of the dorsal valve minute, not prominent, situated about one-third the length of the valve from the cardinal margin.

"Surface marked by fine but very sharply elevated radiating striae, which are sometimes tortuous, and frequently increased by implantation. Ventral valve and interiors not observed.

"This is a distinct and well marked species, not easily to be mistaken for any other now known to me. Its nearest analogue is *C. crenistria* of the Hamilton group; but the striae are sharper, with the apex more appressed, and somewhat differently situated." —Hall, *loc. cit.*

This species is easily recognized by its sharp radiating striae.
1.41C2-3, D2, 3....1.12F3.

CRANIA SCABIOSA Hall.

Plate XXXIII, figs. 3-3a.

Crania scabiosa Hall, 1866, 24th Rep. New York State Museum (advance sheets), p. 220, pl. vii, fig. 15.

"Shell somewhat less than medium size, usually discoid or little elevated, but sometimes prominent, irregular in outline; margin thickened. Apex of dorsal valve eccentric, varying in different individuals. Surface of valve having usually strong lamellose lines of growth, which are sometimes obscured by the roughness of the substance to which the specimen is attached, showing through the shell or causing it to grow irregularly, by which it often assumes the features of the foreign body. Ventral valve unknown.

"This species is not uncommon; usually found attached to shells of other brachiopoda, and sometimes on CHAETETES and other substances. The valves of *Orthis lynx, Orthis occidentalis* and *Streptorhynchus planumbona* are often found with several individuals so crowded together as to give quite an irregular outline to the specimens."—Hall, *loc. cit.*

1.38P....1.33A3....1.41C1, D2, E6....1.12A2, D1-6.

DALMANELLA TESTUDINARIA var. EMACERATA Hall.

Plate XXXIII, figs. 5, 5a.

Orthis emacerata Hall, 1860, 13th Report of the New York State Museum of Natural History, p. 121. (Not figured.)

"Shell semielliptical, length and width about as five to seven; hinge-line nearly equalling the width of the shell. Dorsal valve flat, with a slight depression down the center; area extremely narrow. Ventral valve depressed convex, slightly elevated at the beak, which is inclined over the area, but scarcely incurved; an undefined elevation extending from the umbo towards the front, and sometimes quite to the margin of the shell; area narrow, almost linear.

"Surface finely striated; striae bifurcating, curving upwards, and running out on the hinge-line. Interior of the dorsal valve with two small teeth and a small cardinal process; valves thin.

"This species has the form and general characters of *Orthis testudinaria*; but the shell is much thinner than that species ordinarily is in the same formation, and the striae are finer, there being at least twenty more on the margin in shells of equal size. The depression in the center of the dorsal valve, and elevation in the center of the ventral valve, are far less conspicuous or scarcely marked in some specimens, while the hinge-line is always proportionally longer than in *O. testudinaria.*

"*Geological formation and locality.* In the shales of the Hudson River group near Cincinnati, Ohio. Received from Mr. Carley, and also collected in Iowa and Wisconsin."—Hall, *loc. cit.*

The larger size, greater proportional length of the hinge, and mesial depression of the dorsal valve will sufficiently distinguish this species from the associated *D. multisecta.* It is much less abundant than the latter species.

5.9A14, 37....Also from the Eden shales on Tanner's Creek near Guilford.

DALMANELLA TESTUDINARIA var. MEEKI (Miller).

Plate XXXIII, Figs. 6-6g.

Orthis meeki Miller, 1875, Cincinnati Quarterly Journal of Science, vol. II, p. 20.

"Shell small, plano-convex, rather depressed, transversely truncato-suboval, the length being about five sixths its breadth; hinge line, perhaps, always a little shorter than the greatest breadth of the valves; lateral margins generally rounding to the hinge, most prominent at, or a little behind, the middle, and rounding to the front, which is usually somewhat straightened, or very faintly sinuous at the middle; or, presents a regular semi-circular outline.

"Dorsal valve nearly flat, or slightly convex on each side of a shallow, mesial sinus, that commences very narrow at the beak, and usually widens rather rapidly to the front; beak very small, scarcely projecting beyond the edge of the area, and not incurved; area low at the middle, and narrowing off to nothing at the lateral extremities of the hinge, slightly arched, and directed obliquely backward; foramen very small, and filled by the cardinal process. Interior very shallow, and provided with a slender mesial ridge that extends about half way forward from the hinge, between the muscular impressions, which are not usually well defined; scars of posterior pair of adductor muscles smaller, and usually deeper, than the anterior, and situated close back under the brachial processes; those of the anterior pair three or four times the size of the posterior, suboval in form, and extending to near the middle of the valve; cardinal process very small and trifid; brachial processes, comparatively rather stout and prominent; internal surface having the radiating striae of the exterior rather distinctly impressed through, as it were, in consequence of the thinness of the shell, and finely granular, the granules being apparently connected with the punctate structure of the shell.

"Ventral valve compressed convex, the greatest convexity being near, or a little behind, the middle, along a more or less prominent undefined ridge, that sometimes, but not always, imparts a subcarinate appearance to the central and umbonal regions; beak small, projecting somewhat beyond that of the other valve, abruptly pointed, and rather distinctly arched, but not strongly incurved; area about twice as high as that of the other valve, and with its sharply defined edges sloping to the lateral extremities of the hinge, directed and arched obliquely backward with the beak; foramen having near the form of an equilateral triangle, but rather narrowed upward to the apex of the beak, and partly occupied by the cardinal process of the other valve. Interior showing the teeth to be moderately prominent; concavity for the muscular impressions very shallow, small, somewhat bifid anteriorly, and not defined by a very distinct marginal ridge; scars of divaricator muscles apparently narrow, and situated on each side of a shallow mesial depression, which seems to include, far back at its posterior end, those of the very small adductors, merely separated from each other by a hair line; impressions of the ventral adductor muscles apparently wider and shorter than those of the divaricators; striae and fine granules of the interior as in the other valve.

"Surface of both valves ornamented by numerous, distinct, radiating striae, that usually bifurcate about three times between the beak and the free margins; posterior lateral striae so strongly curved that a part of them run out on the hinge line. Numerous, very minute, regularly disposed, concentric lines may be seen by the aid of a magnifier, most distinctly defined in the furrows between the much larger radiating striae; while a few distant subimbricating, stronger marks of growth are usually seen in the adult shells.

"Length of a medium-sized, mature specimen, 0.60 inch; breadth, 0.75 inch; convexity, 0.25 inch."—Miller, *loc. cit.*

Miller says further that his species is the same as described and figured by Meek in the Ohio Paleontology as *Orthis emacerata* Hall, and that Meek's specimens came from Hamilton, Butler County, Ohio, and (probably) from Cincinnati, Ohio. Meek does not say *where* his types came from. He says that the species occurs at Cincinnati, at an elevation of 250 feet above the Ohio River, and that he has specimens differing but little from the typical form, from higher horizons, both at Cincinnati and Butler

County, Ohio. He also states that he has specimens from near the top of the (Cincinnati) group from Hamilton, Ohio. *Presumably* his types came from these localities.

In regard to the status of this species, it may be said first of all that it is *not Orthis emacerata* Hall, as supposed by Meek. A further complication has arisen, however, owing to the fact that James, in 1879, four years after Miller described his species, described under the name of *Orthis jugosa,* the common form from the Richmond formation, which was included by Miller in his species *meeki.* I am making an effort to obtain both James's and Miller's types in order to ascertain whether there is really a nameable difference between the two forms. In the meantime, if the specimens figured by Meek represent the Cincinnati form, I should be inclined to the opinion that there is very little difference, except in size, between them and the Waynesville form. I believe that I could match any of Meek's figures with specimens from Weisburg, Versailles, or Madison, Indiana. I have reproduced several of Meek's figures, and have given several figures of specimens from Versailles and Madison. The latter would certainly be *D. jugosa,* if we recognize James's name, but for the present I prefer to retain them under Miller's name of *D. meeki.*

1.34A3, 4, 5, 7, 8, 9, 10, 11, B4-5....1.41B1, 2....1.12D1-6, E3.

DALMANELLA TESTUDINARIA var. MULTISECTA (Meek).

Plate XXXIII, figs. 4-4c.

Orthis emacerata var. multisecta Meek, 1873 (James in MS.), Pal. Ohio, I, p. 112, pl. viii, figs. 3a-d.

"This form, although somewhat variable, differs from the last [*Orthis emacerata*] in being smaller, slightly less transverse, and in having its dorsal valve generally flatter, with usually, but not always, a less defined mesial sinus; and its ventral valve with a less prominent mesial ridge. Its surface striae are also a shade finer, and the minute concentric lines in the furrows between the striae more distinct. The granules of its entire internal surface are likewise a little finer and more crowded.

"The cavity for the reception of the muscular scars of its ventral valve is also proportionally a little smaller, and sometimes differs from that of the last, in wanting the bilobed character anteriorly, seen in the same part of that shell. There are, again, some slight differences in the form and proportions of the muscular scars of its other valve, but I am not quite sure that these are constant.

"The external differences mentioned above give these shells a perceptibly different aspect, when we place, side by side, a trayful of each, the form under consideration having altogether a more delicate and less robust appearance. It may be specifically distinct from the last, but I am not clearly satisfied that it is more than a variety of the same. It differs from Mr. Davidson's figures of *O. testudinaria* quite as strongly as the last; but it is possible that both may be only varieties of that species."—Meek, *loc. cit.*

The description given by Meek of this pretty little Brachiopod is entirely adequate. *D. multisecta* is a smaller species than any other representative of the genus in the Cincinnati region. Its nearly circular outline is also a feature that marks it off from the associated *D. emacerata.*

Dalmanella multisecta is the characteristic brachiopod of the Utica formation (Eden shale) of Ohio, Indiana and Kentucky. It is found in nearly every limestone layer in the formation, except in the very lowest part. In many of the layers of the middle and upper Utica this species completely fills the rock. The specimens illustrated are from the upper Utica at Guilford, Indiana, from the top of the railroad cut just south of the station. At this point the species can be obtained by the thousands, in every stage of development from nepionic shells to the adults.

5.9A2, 10, 14, 21, 27, 29, 31, 44....1.34Co, 5, 6, 7, 8, 9, 10, 11, 13....1.38A3, 5, 7, 9, 11, 13, 15, 17, 19, 23, 29, 31, 32, 33, 35, 45, 49, 59, 61.

DINORTHIS RETRORSA (Salter).

Plate XXXIII, figs. 7-7d.

Orthis retrorsa Salter, 1858, Mem. Geol. Surv. Great Britain, II, pt. I, p. 373, pl. xxvii, figs. 3, 4.

"Ventral valve gibbous, the center rather raised. Dorsal flat, broadly depressed along the middle, edge not recurved; beak suppressed; area at an obtuse angle with the valve.

"This variety, if it can be considered so, comes nearest the var. *subjugata* of Hall's descriptions; it is quite distinct from *O. anomala,* Schloth."—Salter, *loc. cit.*

This interesting Orthid seems to be confined to a single layer of the Arnheim formation, where it is fairly common. I can not believe with Davidson and others that this well marked form is merely a variety of *Orthis porcata* McCoy, neither do I entertain Meek's doubts as to its being the species named by Salter. The best available description is undoubtedly that of Meek in the Ohio Paleontology, from which I condense the following description:

Medium size, transversely suboval to subquadrate, the length being about four-fifths the breadth. Hinge-line shorter than the greatest breadth of the valves, with the lateral extremities abruptly rounded, or very obtusely subangular. Lateral margins more or less convex in outline, and rounding to the front, which is regularly rounded, or somewhat straightened along the middle. Valves decidedly unequal or concavo-convex. Dorsal valve evenly convex, most prominent near the middle with the anterior and lateral slopes more gradual than the posterior. Beak incurved; area of moderate height, more or less strongly incurved so as to sometimes stand at right angles to the plane of the valves; foramen broadly triangular. Ventral valve convex at the point of the beak, and thence sloping toward the lateral and anterior margins; the anterior central, and sometimes the lateral regions, being more or less concave; beak obtuse or abruptly pointed, and strongly inclined forward; cardinal area broad-triangular, well defined, flat, and so distinctly inclined forward as to place the apex of the beak some distance in front of the hinge margin. Foramen narrow-triangular, being often a little higher than wide, and extending to the apex of the beak. Interior of the ventral valve with the muscular cavity quadrangular, deep, scarcely reaching to the middle of the valve, and sharply defined by a raised margin, which is perfectly straight and uninterrupted across the front, in some specimens, and reflected toward the beak in others, while its lateral margins are somewhat wavy. Ventral adjustor muscle scars moderately distinct from those of the long triangular diductors. Adductor scars well defined, subcordate, tapering anteriorly to a narrow point between the anterior extremities of the diductors. Hinge teeth apparently rather small and weak. Vascular markings consisting of two principal trunks, starting from the anterior-lateral angles of the muscular cavity, and each immediately dividing so as to send one branch obliquely outward and backward, with more or less subdivisions; and another forward with an inward curve, and also giving off more or less subdivisions on the anterior lateral side. Surface ornamented by rather coarse rounded radiating striae, some of which on the ventral valve are entirely simple, and others bifurcate once or twice; while on the dorsal valve they increase in number by the implantation of shorter ones between the longer. A few rather distinct lamellae of growth are usually seen near the free margins of adult specimens. Under a magnifier minuter concentric lines may be seen crossing the striae and interspaces; very minute granules are also present, having the appearance of minute spine bases that sometimes leave pits when entirely worn off.

1.34B4-5....I have also seen the species rather common at a similar horizon on Whitaker's Branch near Cold Springs, Indiana.

DINORTHIS SUBQUADRATA Hall.

Plate XXXIV, figs. 1-1b.

Orthis subquadrata Hall, 1847, Pal. New York, vol. I, p. 126, pl. xxxii A, figs. 1a-o.

"Subquadrate, the cardinal line forming one side, the sides and base being nearly straight, with the angles rounded; cardinal line less than the width of the shell, extremities curved; area small, partially common to both valves; foramen moderate, triangular, partially common to both valves; dorsal valve nearly flat or slightly depressed near the margin, elevated towards the beak, which is small and well defined; ventral valve regularly convex, with a shallow sinus along the center, producing a slight elevation of the dorsal valve in front; surface marked by uniform subangular radii, which bifurcate near the beak, and again towards the margin, those near the cardinal line curving upwards; radii crossed by fine elevated concentric lines, which are very distinct in the depressions between the rays.

"This form and the three succeeding ones [*O. Occidentalis, O. sinuata,* and *O. subjugata*] are often confounded; but if the following points are observed there will be little difficulty in distinguishing the one under consideration by the external characters, the internal markings being quite distinct.

"The form of a perfect specimen is subquadrate, as shown in the figures; the surface is evenly marked by radii which bifurcate twice, very rarely three times, before reaching the margin: the upper lateral ones curve upwards, so as often to run out upon the cardinal line, or the rounded slope near its extremity. This character is never observed in either of the following species. The visceral impression in the dorsal valve is subquadrangular, and broad below, the base being nearly on a straight line. The foramen of the ventral or convex valve is partially filled by a thick medial tooth, which projects above the plane of the area, and is deeply striated on the two sloping upper and outer sides. * * *"
—Hall, *loc. cit.*

This species is reported by Hall from Cincinnati (?) and Oxford, Ohio, Maysville, Kentucky, and Madison, Indiana. It is in reality strictly a Richmond form, and has never been found below the Liberty formation. Hall in his description has reversed the usage of the terms dorsal and ventral. Otherwise the description is quite satisfactory. The form is easily recognized by its subquadrate outline and depressed form. *D. subquadrata* is first met with a little above the base of the Liberty formation, where it is very abundant, being the dominant Brachiopod; and specimens are occasionally met with throughout the remainder of the Liberty and Whitewater divisions.

1.34A16, 17, 18, 19....1.41A4, 6, 7, 8, C1, 2-3, D1, 2, E2, 3, 6 ....1.12D1-6.

HEBERTELLA INSCULPTA Hall.

Plate XXXIV, figs. 2-2d.

Orthis insculpta Hall, 1847, Pal. N. Y., I, p. 125, pl. xxxii, figs. 12a-c.

"Shell resupinate; dorsal [ventral] valve depressed-convex; beak elevated, not incurved; cardinal line less than the width of the shell; area short; surface marked by fine elevated radii, which are bifid on the umbo, and again regularly bifid or trifid towards the margin of the shell; transversely marked by strong elevated concentric lines, which are particularly prominent between the radii, giving an indented or sculptured appearance to the surface; interior of the dorsal valve showing marks of the visceral impression, which is peculiarly sculptured.

"This species, of which a single valve only has been seen, is so peculiarly marked as not to be mistaken among all the other species of ORTHIS in the lower rocks. The cavity under the foramen is large and deep, marked on its lower and outer extremities by two pointed sacs, and margined by a thickening of the shell around; the visceral impression on the outside of this cavity is of a double auricular form, and sculptured by curved elevated lines. The inner margin of the shell is impressed by the outer radii.

"This very peculiar form is usually associated with the following forms in the Blue limestone of Ohio. [*O. dichotoma, O. subquadrata, O. occidentalis,* etc.] Its very beautiful sculpture, both internally and externally, is sufficient to distinguish it from all other species in the rock."—Hall, *loc. cit.*

The figures given herewith will convey a much better idea of the peculiarly striking vascular markings of this species than any amount of description. Externally the marked crenulation of the striae by strong concentric lamellae is the most conspicuous feature. The general arrangement of the muscular impressions is very much as in *Hebertella occidentalis* and *H. sinuata.*

The most interesting thing with regard to this species is its limited range. So far, with a few possible exceptions, it has been found only in a zone a few feet thick at the base of the Liberty formation. It is taken by Foerste and Nickles to mark the base of this formation. I have collected a specimen from the Whitewater division, at Richmond, that although not well preserved, seems from its external characters to belong to this species. It has never been found, so far as I am aware, below the base of the Liberty formation.

1.34A13a, 13b, 14a, 14b, 15a, 16....1.41B3, C2-3, E4.

HEBERTELLA OCCIDENTALIS Hall.

Plate XXXIV, fig. 4.

Orthis occidentalis Hall, 1847, Pal. New York, I, p. 127, pl. xxxii A, figs. 2a-m; xxxii B, figs. 1a-i.

"Resupinate, transversely somewhat oval, or longitudinally semioval; length and breadth about as 5 to 7; cardinal line equal to the greatest width of the shell; area large, triangular, partially common to both valves; foramen narrow, triangular, reaching to the apex of the dorsal valve; dorsal valve convex towards the beak, and usually flattened or slightly convex towards the margin (in old shells a broad depression in front); beak much elevated, straight, not incurved; ventral valve regularly convex, with a slight depression along the center; beak slightly projecting beyond the cardinal line, and incurved; surface marked by subangular radii, which bifurcate at one-half or two-thirds the distance from the beak to the base; radii crossed by fine sharp elevated concentric lines, which are usually well preserved in the spaces between the radii.

"This species, in some of its phases, approaches in general aspect to the last [*O. subquadrata*], but differs in essential particulars. The length from beak to base is proportionally less than in the last; the depth of the two valves together, when not compressed, is greater; the beak of the dorsal valve is more elevated, the area larger and foramen longer; the beak of the ventral valve is likewise a little more incurved; the radii are stronger, and do not bifurcate near the beak; the concentric elevated lines are sharper and finer; the striae are straight and direct, the last ones not bending upwards as in *O. subquadrata.* As the shell becomes advanced, the dorsal valve presents an increasing depression towards the margin, which finally becomes a broad, not distinctly defined sinus. At the same time the slight depression in the center of the ventral valve, similar to that in the last species, does not reach the margin, and finally becomes obsolete. The slight elevation in front, shown in the last, is exactly reversed in this species.

"These characters, when once observed, will not fail in enabling the student to identify the species, and to distinguish it from any others in the same geological position.

"The internal structure is not as well known as in the last, the interior of the dorsal valve not having been seen. The interior of the ventral valve corresponds in general character to the last; the small medial ventral tooth does not, however, reach as high as the plane of the area, and it is thin and sharp, while the last is thick. The interior surface is marked nearly to the beak with the impressions of the external radii; while in the last these markings reach only a short distance from the margin."—Hall, *loc. cit.*

Here, as in all of Hall's earlier descriptions, the terms dorsal and ventral are used in the opposite sense from their present usage. Between this and *Hebertella occidentalis* var. *sinuata* there is a perfectly graded series of intermediate forms. The character that I have taken as diagnostic of the species *occidentalis* is the presence of a slight sinus in the dorsal valve, usually most conspicuous at a point about a third of the distance from the beak to the front margin, although sometimes extending all the way from a little in front of the beak to the front margin, and with the sinus of the ventral valve producing a pronounced indentation of the margin. The variety *sinuata,* on the other hand, has typically a small fold on the dorsal valve, beginning near the point of greatest convexity of the valve and extending forward to the frontal margin. Transitional forms between the two species are seen in the lower part of the Richmond formation.

Hebertella occidentalis is especially characteristic of the Whitewater division of the Richmond formation, where it is found quite constantly associated with both the long-hinged and the short-hinged (*P. senex*) forms of *Platystrophia acutilirata.* In the upper part of the Liberty this form is found, but its place is soon taken in the lower beds by the small form of *H. sinuata.*

1.34A18, 19, 20, 21, 22....1.41A4, 5, 6, 7, 8, C1, 2-3, D1, 2, 3, E1, 2, 3, 4, 5, 7....1.12D1-6, F3.

HEBERTELLA OCCIDENTALIS var. SINUATA Hall.

Plate XXXIV, figs. 3-3e.

Orthis sinuata Hall, 1847, Pal. New York, I, p. 128, pl. xxxii B, figs. 2a-s.

"Semioval, with a sinus in front; cardinal line scarcely equal to the width of the shell; dorsal area large, triangular; foramen triangular, reaching to the beak, the upper margins sloping rather abrutply from the beak; ventral area narrow linear, foramen broad triangular, with a distinct medial tooth, which reaches as high as the area; dorsal valve convex, its greatest elevation at the point of the beak, which is acute; a depression along the center, which becomes a sinus in older shells; ventral valve regularly convex in young specimens, gibbous, somewhat emarginate and elevated in front in older specimens; surface marked by strong, regular, rounded striae which bifurcate in a nearly uniform manner about half way to the base; striae crossed by elevated sub-imbricating concentric lines. A few imbricating lines of growth are distinct toward the margin of the older shells.

"This species is distinguished from the last by the stronger and more prominent striae, which are likewise more regularly bifurcating. The beak of the dorsal valve is more elevated and acute, giving a greater height to the dorsal area. The ventral valve is about equally convex or gibbous with the last, while it never exhibits any depression along the center. The depression or sinus in the dorsal valve is usually more abrupt, deeper, and often accompanied by a corresponding elevation on the ventral valve, which does not occur in the preceding species [*O. occidentalis*]. The young shells of the species under consideration are more gibbous that the last, and have the beak of the dorsal valve more elevated and acute, differing conspicuously in this respect from the previous one.

"The variations produced by age, and the difficulty of obtaining a series of specimens, often produce a confusion in regard to these similar species, and it will frequently be found a difficult task to make the proper disposition of specimens.

"In the young shells of this species, looking upon the ventral valve, the beak of the dorsal valve is distinctly seen projecting beyond the umbo; but as the shell grows older, this part of the ventral valve becomes gibbous, and projects beyond the line of the beak of the opposite valve."—Hall, *loc. cit.*

The terms dorsal and ventral are here used in the opposite sense from their present signification. This variety is to be distinguished from the species *occidentalis* by the presence of a small fold in the dorsal valve where the latter species has a small sinus. The other distinguishing characters mentioned by Hall will be found to be unreliable, except in the typical Lorraine form of the variety *sinuata.*

This variety was formerly supposed to be restricted to the Lorraine. It is, however, present in the Lower Richmond formation, being replaced in the Whitewater division by the species *occidentalis.* In the Elkhorn division of the Richmond formation, the large, Lorraine type of *H. sinuata* recurs in association with *Platystrophia lynx* (var. *moritura*) and *Platystrophia laticosta.*

1.33A3....1.34A10, 12, 13, 14, 15, 16, B1-3, C14a, 14b.... 1.41A2, 10a, 10b, B3....1.12E3, D1-6, F3, A2.

LEPTAENA RHOMBOIDALIS Wilckens.

Plate XXXIV, figs. 5-5d.

Conchita rhomboidalis Wilckens, 1769, Nachricht von selten Versteinerungen, p. 77, pl. viii, figs. 43-44.

I have been unable, after repeated efforts, to obtain a copy of the above publication in which the original description of this species occurs. I shall be under the necessity, therefore, of departing from the usual procedure of first giving the original description of the species.

This species has been so many times described and is so characteristic that with the excellent figures given herewith very little in the way of further description will be needed.

Leptaena rhomboidalis has the ventral valve convex and the dorsal valve concave as in *Rafinesquina.* In contour the shell presents a very considerable degree of variation. Some specimens are twice as broad as long, while in others the length and breadth are nearly equal. The hinge line is nearly straight, but may make a very slight bend at the beak in some specimens. The area of the dorsal valve is very narrow and of about the same breadth throughout its length. The area of the ventral valve is somewhat broader, especially at the beak. The angle which the two areas make with each other varies with the age of the specimen from an obtuse to an acute angle. At the beak of the ventral valve, in well preserved material, is a well defined circular foramen. The surface of both valves is covered with fine radiating striae, and is especially characterized by broad, rounded, concentric undulations or rugae to the number of five or six (more or less). This latter character gives to the shell an appearance that is extremely striking, and unlike that of any other brachiopod in the Cincinnati region. The striae are crossed by fine concentric lines, giving the entire surface of the shell a beautifully crenulated appearance. The front portion of the valves is abruptly bent dorsad, sometimes at right angles to the plane of the posterior portion of the valves. This feature is not as prominent in the Richmond group specimens as in those of higher formations (Niagara, etc.).

The interior of the ventral valve has a well defined muscular platform extending about half way from the beak to the front margin and quite similar in shape to that of *Rafinesquina alternata*. It is margined by a well defined ridge, and has a low indistinct mesial elevation.

The cardinal process in the interior of the dorsal valve is prominent and bifid, and projects well above the hinge-line. From in front of the process a low round septum extends forward to the geniculation of the valve. Immediately in front of the process this ridge gives off on either side a thick lateral branch that bends outward and then inward so as to enclose a nearly circular pit that lodges the adductor muscle—one on each side of the median septum. Impressions of the Brachia are occasionally seen on the interior surface of this valve.

This species, as ordinarily understood, presents one of the most extraordinary examples of the persistence of a species known. It is known from the Trenton, is common in the Richmond formation, is a characteristic species of the Niagara series, is common in portions of the Devonian rocks and is known from the lower part of the Mississippian system. This is indeed remarkable, if all of these forms are to be referred to a single species. On this latter point there is room for a good deal of question. For my part, I am inclined to think that a careful study of all of these forms will show that they fall into a number of well defined species.

In the Cincinnati series the species is found only in the Richmond formation, and not by any means in all of the members of that formation. It especially characterizes the upper part of the Waynesville formation, but extends for from ten to twenty feet up into the Liberty formation. In the top of the Waynesville formation the species is very abundant.

1.34A10, 11, 12, 13a, 13b, 14a, 14b, 15a....1.12D1-6, E3.

LEPTOBOLUS LEPIS Hall.

Plate XXXIV, figs. 6, 6a.

Leptobolus lepis Hall, 1871, 24th Report of the New York State Museum, p. 226, pl. vii, figs. 19, 20.

"Shell minute, ovate, or broadly elliptical in outline, about three-fifths as wide as long, and seldom exceeding seven-hundredths of an inch in length; moderately convex, the greatest convexity being about one-third of the length from the beak; ventral area thickened; pedicel groove strongly defined; muscular impression broad, extending more than one-third the length of the valve; muscular ridges of the dorsal valve strongly marked, the central one extending two-thirds the length of the shell, the lateral ones diverging from each other at an angle of about forty-five degrees and extending nearly to the middle of the valve. Extremities bifid.

"Surface of valves concentrically marked by fine lines of growth."—Hall, *loc. cit.*

The types of this species are from the Cincinnati group at Cincinnati, Ohio.

1.34C14a.

LINGULA COVINGTONENSIS Hall and Whitfield.

Plate XXXIV, fig. 7.

Lingula covingtonensis Hall and Whitfield, 1875, Paleontology of Ohio, vol. II, p. 67, pl. i, fig. 1.

"Shell rather below the medium size, broadly and very regularly oval, or elliptical in outline, the breadth and length being as three to four, the apex of the shell scarcely more pointed than the basal margin; surface of the valve very regularly convex transversely, but in a longitudinal direction much more prominent toward the beak, becoming gradually more flattened toward the front of the shell.

"Surface of the shell marked by sharply elevated, rather distant, concentric lines; without other markings of any kind; substance of the shell very thin.

"The example used in description appears to be a dorsal valve, and is probably somewhat shorter, and more rounded posteriorly, than the ventral valve. The shell is somewhat remarkable for its regular oval form and symmetrical outline, and in this respect differs from any shell of the genus with which we are acquainted." —Hall and Whitfield, *loc. cit.*

The type is from about twenty-five to fifty feet above low water level of the Ohio River at Cincinnati, Ohio.

I am not sure that I have detected the species in Indiana. Some imperfect specimens from near the water level of the Ohio, opposite the mouth of the Miami River, may belong to this species.

PLATYSTROPHIA ACUTILIRATA (Conrad).

Plate XXXV, figs. 3-3d.

Delthyris acutilirata Conrad, 1842, Jour. Acad. Nat. Sci. Philadelphia, VIII, pt. II, p. 260, pl. 14, fig. 15.

"Ventricose, with about thirty-two sharp, very prominent ribs, and four larger costae on the mesial fold of the upper valve, which is elevated, flattened at the sides, and convex on the back; hinge extremely winged and acute; inferior mesial fold very profound; beaks nearly equally prominent; cardinal area moderate, widest on the inferior valve, profoundly impressed or obliquely inclined.

"*Locality.*—Falls of the Ohio River, Kentucky. Silurian shale."—Conrad, *loc. cit.*

The locality given by Conrad for this common Richmond group species is in error.

This is the most anomalous in form of any species of the Orthidae, and one can readily pardon the early describers for referring it to the genus *Delthyris* (*Spirifer*), for its superficial resemblance to a *Spirifer* is all but complete. The triangular foramina of both areas would, however, distinguish it from that genus, and the internal characters are altogether different.

As shown in the writer's paper on the Morphogenesis of Platystrophia, *P. acutilirata* is a derivative of *P. lynx* through *P. laticosta.* The intermediate forms may be seen in the basal part of the Liberty formation, where *P. laticosta* is, in places, very abundant. All of the specimens of *acutilirata* found at this horizon are of the decidedly angular form of *P. laticosta* and usually not as acuminate or as greatly produced at the cardinal extremities as the form found farther up in the formation and in the lower part of the Whitewater division. The latter form has the plications more rounded and the fold of the dorsal valve and sinus of the ventral valve less strongly accentuated. At the same time the cardinal extremities are sometimes so produced as to cause the breadth to be as great as three times the length of the shell. The angle between the hinge-line and the lateral margin may, in such specimens, be as small as 40°. The number of plications varies from 18 or 19 to 37 or 38, of which three are almost invariably in the sinus, and four on the fold.

For the short winged (gerontic) form found in association with *Rhynchotrema dentata* in the upper part of the Whitewater division of the Richmond, I have proposed the varietal name of *senex*, and it will be found next described under that caption.

1.34A11, 12, 13, 14, 15, 16, 17, 18a, 21, 22, 23....1.41A4, 5, 6, 7, 8, C1, 2, 3, D1, 2, 3, E2, 3, 4, 5, 6, 7....1.12D1-6, F3.

PLATYSTROPHIA ACUTILIRATA var. SENEX n. var.

Plate XXXV, figs. 4-4c.

Platystrophia acutilirata, gerontic form, Cumings, 1903, Amer. Jour. Sci., 4th ser., XV, pp. 36, 37.

This form is so characteristic of the upper part of the range of *Platystrophia acutilirata* that it seems to me best to give it a varietal designation, although in 1903, when I first called attention to the form, I did not think it necessary to call it by any special name. The features that distinguish this shell are as follows:

Though *P. acutilirata* is a much smaller shell than *P. lynx* of the Lorraine, yet the thickening of the shell in gerontic stages is greater both relatively and absolutely. The acuminate cardinal extremities are so thickened that this region of the shell becomes filled up with shelly deposit. The thickening of the central and anterior region of the shell is very great, so that the actual room left for the lodgement of the soft organs of the animal is less than in unthickened shells of a much lower index, and less both relatively and absolutely in gerontic stages than in ephebic stages of the same individual. The convexity of the shell is also considerably greater than in any other type of *Platystrophia,* the height being in extreme cases 1.5 greater than the length, while in *P. lynx* the extreme is 1.04, or height and length nearly equal, and in *P. laticosta* it is 1.14.

The changes in contour due to senescence are profound. The cardinal angle (the angle between the hinge line and the lateral margin of the shell) may be in normal acuminate types of *Platystrophia acutilirata* as low as 45° or even in some cases less; but in the variety under consideration it becomes as great as 84° or even 90°; the extreme variation is perhaps from 40° to 90°. This of course produces a most striking difference in the appearance of the shell, and is liable to cause the careless collector to confuse this variety with *P. lynx,* from which, however, it differs radically in derivation. Probably the onset of unfavorable conditions, which are manifest in the changed lithological character of the beds containing this variety, as well as in the coming in of a more strongly molluscan fauna, is largely responsible for the peculiar modification of the shell in *Platystrophia,* which characterizes the present variety.

1.41A8, D3, E1, 2, 3, 4....1.60H11.

PLATYSTROPHIA COSTATA Pander.

Plate XXXV, figs. 6, 6a.

Porambonites costatus Pander, 1845, Beitrage zur Geognosie des russischen Reiches, p. 96, pl. xi, fig. 3.

I have been unable to obtain the publication in which the original description of this species is given. In 1902 I had an opportunity to consult this rare work and I have published a tracing of the original figure, in my memoir of the genus *Platystrophia.*

This little species, the *P. dentata* of Meek (*P. crassa* James) is characterized most of all by its small plump shell with only one plication in the sinus and two on the fold. The hinge line is usually slightly shorter than the breadth of the shell farther forward. The form of the areas and the strength of the plications is relatively about the same as in the other species of the genus.

Very little is known about the interior of the valves.

I have not collected any specimens of the typical form of this species from any point in Indiana. In the lower part of the Lorraine I have found an occasional specimen suggesting a diminutive variety of this species, and I have listed them under this name. They have the same number of plications and one plication in the sinus, but are not as plump as the typical form.

The typical (American) form is found at Cincinnati in the Fairmount division of Nickles, that is in the lower part of the Lorraine division, often, as I am informed, in considerable numbers. The Dyer collection, at Harvard, contains great numbers of this species, from Cincinnati.

1.34C13, 14a.

PLATYSTROPHIA LYNX (Eichwald).

Plate XXXV, figs. 1-1g, 7-7c.

Terebratula lynx Eichwald, 1830, Naturhistorische Skizze von Lithauen, Volhynien und Podolien, p. 202, foot note. (Not figured.)

"*Spirifer, cardine elongato, recto, vertice utriusque valvae prominulo, utraque valva sulcata, stratis singulis transversis ex* *testae incremento exortis, numerosissimis, margine dentato; media parte unius valvae prominula, quadrisulcata, alterius vero parte eadem exclavata, profunda.''*—Eichwald, *loc. cit.*

I have pointed out in my paper on the Morphogenesis of Platystrophia that in all probability the original types of both *P. biforata* and *P. lynx* belong to the *biplicate* form of the genus. The evidence for this is the fact that all of the Russian specimens, whether of *P. biforata* or *P. lynx,* seen by me are of the form mentioned. It is doubtful if the question could be settled any more satisfactorily even by an examination of the original types themselves, since the critical character which distinguishes the biplicate and triplicate types of the genus, namely the method of origin of the plications of the fold and sinus at the beaks of the valves, is quite likely to be obliterated in the genotypes, which in the case of both *P. biforata* and *P. lynx* were found in the drift. However this may be, there is no ground upon which a distinction may be based between the two types excepting the one mentioned. In this country the form so common at the tops of the hills at Cincinnati has always been referred to the species *P. lynx.* This is the form which presents gerontic modifications and consequently exceptional thickening of the shell and an exceptional robustness of contour, as pointed out in my memoir on the genus. It does as a matter of fact closely resemble in general appearance the Russian form to which Eichwald applied the name of *Terebratula lynx.* If the Russian form is of the same biplicate type as *P. biforata* of Schlotheim, there is no reason for separating the two specifically, and the name *lynx* falls to the ground unless we retain it as I have done for the multiplicate forms of the American Ordovician having *at the beak* one plication in the sinus and two on the fold, and at the front usually three plications in the sinus and four on the fold. *P. biforata* will then indicate the form with two plications in the sinus and three on the fold *at the beaks* and a variable number further forward. The reasons for this restriction are fully set forth in my paper on the genus and cannot be repeated here. The usual distinction which paleontologists have attempted to make between *P. biforata* and *P. lynx,* based on the general form and number of plications of the shell is of no value whatever in a species so variable. *P. lynx* as thus redefined by me will include not only the Cincinnati form mentioned above, but all American Ordovician forms having usually more than two plications in the sinus at maturity, and a hinge line of moderate length, together with a moderately low fold and sinus. This includes forms heretofore referred to both *P. lynx* and *P. biforata* by workers in this country. The only American Ordovician form that belongs to *P. biforata* as above defined is a small form found in the basal part of the Ordovician in the Champlain basin and Canada. The distinction between *P. lynx* and the other associated forms in the Ordovician rocks of this country will be sufficiently evident from the figures and descriptions of these associated forms, and the present species may therefore be passed over without further comment.

The range of *Platystrophia lynx* is considerable. Small, but typical forms are found commonly in the Trenton of New York, Canada, Minnesota, Kentucky, Tennessee, etc., and the species is very common in the Lorraine. I have shown also that a variety of this species, very closely related to the typical form (var. *moritura*), occurs in the extreme upper part of the Richmond formation. In the Indiana region the chief horizon of *Platystrophia lynx* is in the upper part of the Lorraine, where it is often very abundant and of large size. The best locality known to me for obtaining large numbers of this species is at Vevay, near the tops of the hills. Here I have collected thousands of good specimens. Nowhere in Indiana have I found more than a very few specimens of the very gibbous form of this species that characterizes the top of the Lorraine on the highest hills at Cincinnati (Mount Auburn). I may remark in this connection that at Georgetown, 40 miles east of Cincinnati, along Straight Creek below Arnheim, the zone characterized by the gerontic *lynx* seems to be separated by a very considerable thickness of rock from the zone of the normal form of this species, and along Tanner's Creek the only specimen of the gerontic form that I have seen is also from a horizon considerably above that of the normal form, in what I have called the *Rafinesquina* zone. In his paper on the Geology of Cincinnati Nickles lists *P. lynx* from the Mt. Auburn beds only, with a variety from the Bellevue beds, some 60 feet lower down in the section. What he means by this variety, I do not profess to know. If it is the normal form of the species, the two are evidently separated in the Cincinnati section by about the same interval as in the other sections mentioned, and the Bellevue would correspond to the top of my *Platystrophia* zone.

1.33A3....1.34B1-3, 14b....1.12A2....1.38Ba-h.

PLATYSTROPHIA LYNX var. CYPHA (James).

Orthis (*Platystrophia*) *cypha* James, 1874, Cin. Quar. Jour. Sci., vol. I, p. 20. (Not figured.)

"Shell medium size; extremely gibbous; hinge line forming spine-like projections, being over two thirds longer than the greatest breadth of the shell below; shell broader than long; convexity equaling the body below the hinge extensions; cardinal area narrow, and finely striated at right angles with the length. Dorsal valve, remarkably elevated mesial fold, with slopes commencing a little below the beak, and extending to the front, at an angle of about 80 degrees to the main body of the shell, where they turn at nearly right angles and continue to the free margins; beak incurved, not elevated above the other valve; the mesial fold consists of two costae. Ventral valve, beak incurved, not elevated, nearly in contact with the other valve. Sinus very profound, extending to the front, which is bent over to nearly half the thickness of the shell beyond the cardinal line of the dorsal valve; one strong elevated plication in the center of the sinus, and an obscure rudimentary one on each side; lateral slopes concave.

"Twenty-two to twenty-six angular costae on each valve, about eight of which commence on the cardinal line, and do not extend to the beak.

"The line of junction of the two valves is nearly flat, or slightly rounded, and has a remarkably zig-zag appearance, forming, where the sinus and mesial fold join, the letter W.

"Interior unknown.

"Width along the cardinal line one and a half inches, half way below the hinge line less than one inch; length three quarters of an inch.

"This shell resembles somewhat some of the larger specimens of *O. crassa,* Meek, but it is more gibbous, has a more profound and lengthy sinus, greater length of hinge line, and finer and more numerous costae."—James, *loc. cit.*

I have recently received from Dr. Weller, of the University of Chicago, the type lot of this variety from the James collection. Among the several specimens represented in this type set are a couple corresponding exactly to my form *unicostata,* mentioned and figured in my paper on the genus *Platystrophia,* one fairly typical though rather short example of *P. acutilirata,* and a specimen of *P. laticosta.* Since the description given by James applies especially to the form with one plication in the (very profound) sinus (my form *unicostata*), it may be well to recognize James' name as a varietal designation. The variety differs from the typical *laticosta* only in the somewhat greater depth of the sinus, and in the presence of only one plication in the sinus. It does not bear any close relation to *P. costata* (the *P. crassa* of James).

I have usually found the form in the upper part of the Lorraine, sometimes in association with *P. lynx* and *P. laticosta.*

PLATYSTROPHIA LYNX var. LATICOSTA (Meek).

Plate XXXV, figs. 2-2b.

Orthis (*Platystrophia*) *laticosta* Meek, 1873, Pal. Ohio, vol. I, p. 116, pl. x, figs. 4a-f.

"This form scarcely attains to more than two-thirds the bulk of the largest specimens of the var. *lynx,* and is always less gibbous, proportionately wider on the hinge line, with more angular posterior lateral extremities, and, even in the largest individuals, it is a much thinner shell. It likewise differs in having its mesial sinus wider and much more profound at the front, and its mesial fold more elevated and angular; while its lateral slopes are decidedly more compressed, those on each side of the sinus being always concave, and the margins of the sinus very prominent and angular, which, together with the prominence of the mesial fold, and the greater length of the hinge line. impart a general angularity of appearance not seen in the var. *lynx.* In the sinus there are nearly always three plications, the lateral two being smaller than the middle one, or sometimes rudimentary; while occasionally one of them is obsolete, leaving the large one, as usual, in the middle, and a smaller one on one side only. The mesial fold has generally four plications (never more), the middle two being usually larger and more prominent than the others, and separated by a larger and deeper furrow. Its lateral slopes have generally only from five to seven large, simple, angular plications on each side of the fold and sinus; these being decidedly larger than on specimens of the var. *lynx,* of corresponding size.

"Internally, the ventral valve of this variety only differs from that of the var. *lynx,* in having the cavity for the muscular scars much less deeply impressed, owing to the fact that the shell did not thicken within, as in that form, as it advanced in age. The interior of its dorsal valve shows the same rudimentary cardinal process; while its muscular scars (which I have not seen in this valve of the var. *lynx*) are moderately defined, the posterior pair being corrugated, and much larger, as well as more widely separated, than the anterior.

"In figuring this variety in the first volume Paleont. New York, Prof. Hall compares it with the var. *dentata* of Pander, mentioning some points of difference. It attains a much larger size, however, than that variety, and differs in having nearly always three plications, instead of only two, in the sinus, which is deeper, and its mesial fold more prominent, thus giving the general aspect of the shell greater angularity of outline.

"The specimens for which Mr. James retains the name *O. profundo-sulcata*, in his list, are much smaller than the average size of the form here under consideration; but, with that exception, and their usually rather shorter hinge, and somewhat less compressed lateral slopes, they seem to me to differ very little, if any, from specimens of the same size of the variety under consideration. On the other hand, they only differ from the young of the variety *lynx* in generally having the mesial sinus deeper, and the fold more prominent, with, perhaps, in most cases one or two plications less on the lateral slopes. I have, therefore, found it very difficult to distinguish this as a variety from young or dwarfed examples of the varieties *lynx* and *laticosta,* though its more prominent fold, etc., bring it nearer the latter. Figs. 2 *a, b, c, d,* of plate 10 [of Meek's paper], show the form and usual size of this variety. It occurs 300 feet above the Ohio, at Cincinnati.

"Length of the largest example seen, 0.86 inch; breadth (at hinge line), 1.40 inches; convexity, 0.88 inch."—Meek, *loc. cit.*

In my memoir on the Morphogenesis of *Platystrophia,* I have discussed this variety and its phases at some length. In my paper with Mr. Mauck on the variation of *Platystrophia,* I have shown that this variety is connected by an indefinite number of intermediate forms with the typical *P. lynx.* A real new species is achieved in *P. acutilirata,* between which and *lynx* the present form is transitional.

Platystrophia laticosta is a very persistent form. It is found first in the lower part of the Lorraine—a very small form. In the middle and upper part of the Lorraine it is found in association with the normal form of *P. lynx,* and it is here also that the greatest number of transitional forms to the last named species are seen. In the top of the Lorraine, *P. lynx* disappears, but *P. laticosta* is still found sparingly in the Arnheim formation. In the greater part of the Waynesville formation all forms of *Platystrophia* fail, but in the upper part of this formation *P. laticosta* reappears in great numbers and typical form, though not attaining as great size as in the upper part of the Lorraine. From this point it continues till well toward the top of the Liberty formation. There is then another hiatus in the Whitewater division, where *P. acutilirata* is dominant. The final appearance of *P. laticosta* is in the Elkhorn division of the Richmond, where it is once more common, being here also once more associated with *P. lynx.* In the Saluda formation *P. laticosta* is also present at one or two levels. The occurrence of this fossil is thus seen to be extremely interesting.

1.33A3....1.34A8, 10, 11, 12, 18b, 22, B1-3, C13, 14a, 14b.... 1.41A10a, 10b, B1, 2....1.12A2, F3, D1-6, E3....1.38A63, 73, 83, Ba-h....1.60H11.

PLATYSTROPHIA LYNX var. MORITURA n. var.

Plate XXXV, figs. 5, 5a.

Platystrophia lynx, upper Richmond form, Cumings, Amer. Jour. Sci., 4th ser. XV, pp. 24, 25.

This form of *P. lynx* is perhaps sufficiently distinct to warrant a varietal designation; at least such a designation will be a matter of great convenience in as much as the form marks a very definite zone at the extreme top of the upper division (Elkhorn) of the Richmond formation. In my paper on the Morphogenesis of Platystrophia (1903) I have this to say of the present variety:

"In the extreme upper part of the Ordovician (Madison beds) of Richmond, Weisburg and Laurel, Indiana, the writer found a variety of *Platystrophia lynx* which is of exceptional interest. As is well known, the so-called Richmond beds (*Rhynchotrema* zone) contain exclusively the variety *acutilirata* associated almost constantly with *Hebertella occidentalis.* At about 50 ft. below the Clinton at Laurel and about 13 ft. to 15 ft. at Richmond, comes in a large and decidedly transverse variety of *P. lynx* associated with *Hebertella sinuata.* This association is a point of great importance since it shows that these two forms of *Platystrophia* and *Hebertella,* so constantly met with together in the Lorraine, have lived on together at some point through the *Rhynchotrema* hemera and here under a recurrence of favorable conditions reappear, the former with some modification, the latter with scarcely any.

"This form of *Platystrophia lynx* has eight to eleven plications on the lateral slopes, and the index may be as great as 1.9. A number of individuals (5 out of 100) show a reduction of the lateral plications of the fold and sinus. * * *

"That such a tendency to eliminate plications should affect 5 individuals out of 100, while in the Lorraine not more than one out of a thousand exhibits anything analogous, is certainly not without profound significance. There are in the present collection two specimens of *Platystrophia lynx* from Vevay, Indiana, both of which have three plications on the fold: One individual has four in the umbonal region; and the other never developed but three at any stage. The first has an abnormally low index (1.1) and bears every evidence of lateral cramping during growth. This would account for the failure of the fourth plication. The early growth stages of the second specimen also show an abnormally low index and the failure to develop the full number of plications is therefore probably due to the same cause. The Richmond shells, on the other hand, are very transverse at all stages, especially so in the adult. The correct explanation of the obsolescence of plications in this type as well as in the *laticosta* and *costata* types where it is still more pronounced, is probably to be sought in a readjustment of the brachia, producing an elevation and narrowing of the fold."—Cumings, *loc. cit.*

The distinctive characters of this variety by which it may be readily recognized, are the proportionally great breadth of the shell, and the less convexity of the valves, together with a proportionally narrower fold and sinus with a tendency to obsolescence of the lateral plications of the same. It can be distinguished from the *P. acutilirata* var. *senex,* by the much greater gibbosity of the latter and the presence of growth varices near the beak which have a decidedly lower cardinal angle than that of the adult. This latter character infallibly differentiates the two forms when the shell is well enough preserved to show it.

This variety of *P. lynx* presents the closest resemblance to *P. biforata* of the Silurian, of any form known to me. It is, however, very distinct from the latter species. *P. biforata* as restricted by me (loc. cit. pp. 41-44) has always *at the beak* three plications on the fold and two in the sinus, while *P. lynx* and all the other Ordovician species and varieties above the basal Trenton, have always *at the beak* one plication in the sinus and two on the fold, no matter how many there may be farther forward.

Since my paper on *Platystrophia* was published in 1903, I have made a more extensive study of the Saluda formation in which I supposed this species occurred, with the result that, as explained elsewhere, I have come to the conclusion that there is a well defined faunal zone above the typical Saluda, and that it is in this upper zone that *P. moritura* occurs. This can be best seen at Richmond, because it is there that the *moritura* zone is typically developed, and most completely marked off from the underlying zones. From about Osgood northward, however, there is in the upper part of what has been heretofore designated the Madison beds or Saluda formation, a zone of rather barren, dark colored limestone in which the present form, together with its nearly constant associate, *Hebertella sinuata,* is found. This is, I believe, the southern representative of the Elkhorn division of the Richmond section. It will be noted in this connection that, according to my studies, the Whitewater division of the Richmond series is *above* and not below the typical Saluda; in other words that the Saluda is represented in the Richmond section by the massive bed of limestone about 130 feet below the Clinton, this latter bed being the true horizon of *Tetradium minus.*

1.41A10a, 10b, and at the top of the Ordovician section about Laurel, Hamburg, and Osgood.

PLECTAMBONITES SERICEUS (Sowerby).

Plate XXXVI, figs. 1-1c.

Leptaena sericea Sowerby, 1839, Murchison's Silurian System, p. 636, pl. xix, fig. 1.

"Semicircular; finely striated longitudinally, with a silky lustre; a few striae deeper than the others; larger valve convex. the other nearly flat; front not concave, considerably deflected at the edge. Length 5 lines, width 10 lines.

"In general form this resembles *L. lata* of the Ludlow Rock, but has much finer striae and more angular sides. The front also is straighter, and there are no indications of spines. Sometimes a few concentric lines of growth are conspicuous."—Sowerby, *loc. cit.*

The most interesting fact in regard to this species is its great range and distribution. It was described from British specimens. but occurs commonly at a number of levels in the Ordovician of this country ranging from the Trenton to the Richmond. The only other species known in the Cincinnati group is *P. plicatellus* Ulrich, a small species found in the lower Eden shales. Near the base of the Liberty division of the Richmond, *P. sericeus* comes in in such immense numbers in a number of layers, and especially in the top of a strongly wave-marked layer, as to completely fill the rock to the exclusion of almost every other fossil. This horizon is one of the most constant and readily traced of the entire Cincinnati group. My description and figures are drawn from specimens taken from this horizon at Versailles.

The most striking superficial characteristic of the species is that mentioned by Sowerby, namely, the silky luster due to the finely fibrous nature of the shell substance and the unusually smooth and glossy surface, with its very fine striae. The general aspect of the shell is decidedly transverse, except in young specimens, the breadth being ordinarily twice the length. In young specimens the length and breadth may be nearly equal. The cardinal line is ordinarily straight, only occasionally slightly arched. Greatest breadth at the hinge. The cardinal angles are usually slightly auriculate, and often sharply pointed. The contour of the lateral and anterior margins varies from smoothly rounded or nearly semicircular to subrectangular. Dorsal valve concave, especially so in fully mature specimens. Beak obsolescent, and area very narrow. Interior of the dorsal valve with a zone of small but distinct pustules over the anterior and lateral portions, arranged in a somewhat radial manner. Cardinal process conspicuous, triangular, trifid at the apex, and merging laterally with the crura which are pointed laterally outward in a line parallel with the hinge line. The lamellae arising from the anterior margins of the crura run forward and inward so as to nearly meet in the median line of the valve, enclosing together with the cardinal process a distinct triangular pit, lying directly in front of the process. These lamellae are continued forward as two prominent ridges, slightly diverging, to near the front of the valve, where they become, in old shells, much thickened, and often support a number of tubercles. The internal adductors were inserted between these ridges; and outside of them, sometimes outlined by a well defined ridge are the impressions of the external adductors. In the middle of the interior impression is to be seen, in well preserved specimens, a third ridge, or septum, very much smaller and thinner than the other two, but of about the same length.

The ventral valve is convex, somewhat more strongly curved than the other valve. Area narrow. The interior of this valve does not present the interest of the dorsal valve and it is much less often seen in collections. The teeth are small. Arising from the bottom of the valve directly beneath each tooth is a small ridge extending obliquely forward and outward about one-third of the way across the valve. In the median line of the valve a third ridge arises at the pedicle opening and after running forward about a third of the way to the front of the valve bifurcates, the two branches running for a short distance nearly parallel with the ridges mentioned above. These ridges are thus seen to bound the two diductor scars.

Surface of both valves ornamented with excessively fine radiating striae, every fourth or fifth one being slightly larger than the others.

5.9A2, 6, 8, 10, 14....1.34A9, 15b, 16a, 16b, 17, 18a, C6.... 1.41B1, C1, 2-3, D2, E4....1.12E3, D1-6, F3....1.38A3, 11.

PLECTORTHIS ELLA Hall.

Plate XXXVI, figs. 2-2c.

Orthis ella Hall, 1860, 13th Report of the New York State Museum of Natural History, p. 121. (Not figured.)

"Shell small, ovate: valves nearly equally convex; hinge-line extremely short, being scarcely more and sometimes less than one-third the width of the shell, and scarcely affecting the contour of the margin, which slopes from the beak of the ventral to the lateral margins a little above the middle of the valve. Dorsal valve gibbous subcircular; the beak extending a little above the hinge-line, and the area extremely short. Ventral valve broadly ovate, sloping from the beak; beak produced beyond the line of the opposite valve, and pointed, not incurved; area twice as long as high; foramen narrow and extending to the apex of the beak, and sometimes truncating the extremity.

"Surface marked by from fifteen to twenty simple, abruptly rounded or subangular plications.

"This small *Orthis* is so peculiar, as not to be readily mistaken for any other known in our strata. The short hinge-line and area, and produced beak of the ventral valve, are characteristic features. In some specimens the area is obscure or undefined, and the shell has much the aspect of TREMATOSPIRA. It is a rare species, and I have not seen more than twenty individuals, all of which preserve the characters given above, the variation being mainly in the number of striae: those with fewer striae are frequently more gibbous than the others. Length about one-third of an inch; the width a little more.

"*Geological formation and locality.* In the calcareous shales of the Hudson-river group, near Cincinnati, Ohio. From the collections of Mr. S. T. Carley and Mr. U. P. James."—Hall, *loc. cit.*

The above description, which is based on Cincinnati specimens, does not need any additions. I have doubtfully referred several imperfect specimens from the top of the Lorraine at Vevay to this species.

PLECTORTHIS PLICATELLA Hall.

Plate XXXVI, figs. 3-3f.

Orthis plicatella Hall, 1847, Pal. New York, I, p. 122, pl. xxxii, figs. 9 a-g.

"Broadly semioval, nearly equivalve, length and breadth about as 3 to 4; surface marked by strong radiating plicae, which are usually simple, about 20 to 28 on each valve, crossed by simple elevated concentric lines, which are more distinct in the depressions between the costae, and often obscure or obsolete upon their exposed surfaces; valves nearly equally convex, without sensible depression or elevation on either one, meeting at the edges in a straight line; cardinal line not extending beyond the width of the shell; area narrow; dorsal foramen extending to the beak.

"This species bears some resemblance to *Orthis radians* of SOWERBY, but it proves clearly distinct on comparison with his description; the plications are never so few as 15, and the shell is never concave in front. The equal convexity of the valves, and uniform, strong, somewhat sharp plications, are distinguishing characters. The proportionate greater extension of the hinge line, and less distance from beak to base, distinguish this shell from any variety of *O. pectinella,* even when the surface only can be seen." —Hall, *loc. cit.*

This species occurs quite commonly in the Lorraine, especially the lower part, associated with *Platystrophia laticosta.*

1.34B1-3, C13, 14a....1.38Ba-c....1.12E3.

PLECTORTHIS PLICATELLA var. TRIPLICATELLA (Meek).

Plate XXXVI, figs. 4-4b.

Orthis triplicatella Meek, 1872, Amer. Jour. Sci., 3d ser. IV, p. 281. (Not figured.)

"Note.—Among the specimens sent to me from Cincinnati, Ohio, by Mr. A. S. Miller of that city, there are two examples of an *Orthis,* agreeing in form and general appearance with *O. plicatella,* but differing in being considerably larger, and in having a *decidedly* lower ventral area, with the beak of the same valve more incurved than in any authentic specimens of that shell I have ever seen. It also presents a curious triple arrangement of the costae, caused by each of them giving off a smaller one on each side at about half the distance between the beak and the free margins, the main rib always continuing larger and much more prominent than the others to the margin; while the spaces between each bundle thus formed are proportionally wider and deeper than we see in *O.*

plicatella as usually found. These characters give this shell a peculiar appearance that leads me to think it will probably be found to belong to an undescribed species. As I know nothing of its internal characters, however, and the species of this type of *Orthis* are known to be quite variable, I feel some doubts about the propriety of describing it as a new species. It seems to me, however, to differ from the *O. plicatella* and *O. fissicosta* in more important characters than they differ from each other. Should other collections show this form to be a distinct species, I would propose for it the name *O. triplicatella.*

"The larger of the two specimens seen measures 0.70 inch in length, 1.40 inch in breadth, and 0.40 inch in convexity."—Meek, *loc. cit.*

1.34C13, 14a.

RAFINESQUINA ALTERNATA (Emmons).

Plate XXXVII, fig. 1-1e.

Strophomena alternata Emmons, 1842, Geol. N. Y., Rep. 2d District, p. 395, fig. 3.

"No. 3. *Strophomena alternata,* whose striae or markings are alternately fine and coarse. This character is possessed, however, by other species, and hence is not in itself to be relied upon as specific."—Emmons, *loc. cit.*

This is, with the possible exception of *Zygospira modesta,* the commonest and most widely distributed brachiopod of the entire Ordovician system. Its range extends from the Trenton to the Richmond, both formations inclusive; and it is common in both Europe and America wherever the Ordovician rocks are exposed.

The original description by Emmons would not serve to identify the species, but fortunately Emmons accompanied it with a good figure, which I reproduce (plate xxxvii, fig. 1b) together with figures of several specimens from the Ordovician of Indiana. The figure of Emmons shows a shell with a ratio of length to breadth of 1.35, and with the lateral slopes at very nearly a right angle to the hinge line which is perfectly straight. The figure also indicates a shell of only moderate convexity. According to Hall (1847), the length and breadth are about as 12 to 15 (ratio 1.25), and the hinge line is a little longer than the width of the shell farther forward, and slightly reflected at the extremities. "Dorsal valve depressed convex, sometimes more convex in the middle, suddenly deflected near the margin and flattened toward the cardinal line;

ventral valve concave, gradually or sometimes suddenly inflected towards the basal margin [the terms dorsal and ventral are here used in the opposite sense from their present usage]; surface marked by fine rounded radiating striae, which alternate at unequal intervals with coarser ones; striae increasing in number toward the margin of the shell, crossed by fine elevated concentric lines and a few imbricating lines of growth."—(Hall, *loc. cit.*, p. 102.)

Among the innumerable forms of this ubiquitous species it is often difficult to say whether one is dealing in any given case with the species *alternata* or with some variety. The form figured by Emmons seems to be a sort of average or model form, for the shell index (ratio of length to breadth) varies widely both in the direction of a less and of a greater ratio. The convexity may be much less and is also often much greater, as is indicated by the figures. The hinge line may be much shorter than the width of the shell farther forward, or it may be much longer. The shell may be very thin and fragile (as in the variety *fracta*) or very strong and massive (as in the form called *ponderosa*). Where these differences are well marked they have been distinguished by varietal designations; but it must be confessed that forms are constantly met with that can with difficulty be placed in any of the published varieties; and one must either put a very liberal interpretation upon the limits of these varieties or be constantly making new varieties. I have preferred the former course.

5.9A21, 31, 37, 41, 44, 50....1.33A3....1.34A1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22....1.34B1-3, 4-5....1.34C5, 8, 9, 10, 13, 14a, 14b....1.41A4, 5, 6, 7, 8, 9, 10a, B1, 2, 3, C1, 2-3, D1, 2, 3, E1, 2, 3, 4, 5, 6, 7....1.12A2, D1-6, E3, F3. and practically all other localities where the Cincinnati series is exposed.

RAFINESQUINA ALTERNATA var. FRACTA (Meek).

Plate XXXVII, figs. 5, 5a.

Strophomena alternata var. *fracta* Meek, 1873, Pal. Ohio, I, p. 91, pl. vii, figs. 3a-e.

"Very thin and fragile, smaller than the typical form, much compressed, decidedly semi-oval, the length equalling or slightly exceeding the breadth; lateral extremities rectangular, and not deflected; lateral margins generally straight or a little convex in outline behind, and rounding forward to the regularly rounded front; surface as in the typical form, excepting that there are usually more strongly marked imbricating laminae of growth around near the free margins; interior of dorsal valve with muscular scars removed proportionally farther forward from the cardinal process than in the typical and other varieties.''—Meek, *loc. cit.*

This form occurs, sometimes in immense numbers, in the upper part of the Lorraine formation. It is often difficult even among thousands of specimens to find a single perfect one, owing to the exceptionally fragile nature of the shell.

1.33A3....1.34B1-3, 4-5, 1.34C14b....1.38P.

RAFINESQUINA ALTERNATA var. LOXORHYTIS (Meek).

Plate XXXVII, figs. 2, 2a.

Strophomena alternata var. *loxorhytis* Meek, 1873, Pal. Ohio, I, p. 91. (Not figured.)

''Attains a large size, moderately convex antero-centrally, or rather depressed; much extended on the hinge line, with lateral extremities acutely angular, flattened and scarcely deflected; area very narrow; both valves marked near the cardinal margin, toward the lateral extremities, by six or eight distinct, very oblique wrinkles on each side.''—Meek, *loc. cit.*

Miller states that this form is found in the upper part of the Cincinnati group, about 600 to 800 ft. above low water mark in the Ohio River (at Cincinnati), and that it is not common. The form of which figures are given herewith is from the Waynesville formation. I have not seen any form at a lower level that seemed to me to answer to Meek's description, although Nickles lists it from the Lorraine (Fairmount division). The Richmond form seems to me to correspond very closely to Meek's description, except that the oblique wrinkles at the lateral extremities are faint or lacking. It appears to the writer, however, that such wrinkles are apt to occur in old shells of almost any species of *Strophomena* or *Rafinesquina,* and are not diagnostic.

RAFINESQUINA ALTERNATA var. NASUTA (Conrad).

Plate XXXVII, fig. 4.

Strophomena nasuta Conrad, 1842, Jour. Acad. Nat. Sci. Philadelphia, VIII, pt. II, p. 260. (Not figured.)

''Triangular; longer than wide, slightly winged; inferior valve with the umbo and disc flattened; towards the base suddenly and concentrically bent towards the upper half; concentrically wrinkled; radii distinct, rather remote, with three or four minute intermediate lines; base projecting and angular in the middle.

"This species resembles *S. alternata* and *S. deltoidea* in having one or two of the central lines larger than the rest, but it is a much flatter and proportionally longer shell."—Conrad, *loc. cit.*

The comparison of this shell with the typical *R. alternata* of the Cincinnati group shows that it is a somewhat smaller form, characterized especially by the drawing in of the anterior-lateral margins so as to give it a somewhat triangular aspect, as indicated by Conrad. The middle portion of the anterior margin may even be produced into a distinct lobe. The valves are also decidedly more abruptly deflected at the anterior third than is the case in the typical form, thus greatly increasing the convexity of the ventral valve, and to a less degree the concavity of the dorsal valve. The space between the valves is accordingly relatively greater than in the typical form. In surface ornamentation the variety does not differ materially from *R. alternata.*

Found in the middle part of the Lorraine. 7.33A3....1.12A2 ....1.34C14b....1.34B1-3....1.38P.

RAFINESQUINA ALTERNATA var. PONDEROSA.

Plate XXXVII, figs. 3, 3a.

I am not sure that this is the form that has received the name *ponderosa* from collectors and was figured under this name by Hall in 1847. The name has never been formally proposed, so far as I am aware, and I therefore here propose it for the fairly well characterized form of *Rafinesquina alternata* common in association with *Platystrophia lynx* and *Hebertella sinuata* in the middle part of the Lorraine (Bellevue).

It differs from the normal type of the species in much the same way that the very gibbous *Platystrophia lynx* of the "lynx" beds does from the normal form of that species: that is, it is very massive, as compared with the normal form, and all the muscular and vascular markings are very deeply impressed. The cardinal process is unusually large. The general outline of the shell is not particularly different from that of the normal form of the species. I should not say, as Hall does, that it represents merely the old individuals of the normal form, but that it represents a gerontic phase of the species that affected nearly all of the individuals at certain horizons.

RETZIA GRANULIFERA Meek.

Plate XXXVI, figs. 5-5c.

Retzia (*Trematospira*) *granulifera* Meek, 1872, Proc. Acad. Nat. Sci. Phila. (February, 1872), p. 318. (Not figured.)

"Shell transversely oval, the length being about four-fifths the breadth, moderately convex, the convexity of the two halves being very nearly equal; lateral margins rather narrowly rounded in outline; front and anterior margins broadly rounded, or perhaps the former sometimes straight or slightly sinuous in outline in the middle; cardinal margin nearly straight on each side, and sloping at an agle of about 140° from the beaks toward the lateral extremities. Dorsal valve nearly evenly convex, its greatest prominence being perhaps slightly behind the middle; provided with about thirteen simple, angular, radiating plications or costae, five of which on the middle are smaller than the others (the middle one being smallest and not continued to the beak), and form together a very low, flattened mesial elevation, scarcely rising above the general convexity; beak rather strongly incurved. Ventral valve of much the same form as the other, excepting that its beak is somewhat more prominent, perforated, and incurved upon that of the other valve; while two of the middle costae are much smaller than the others, and the first one on each side of these is intermediate in size between the smallest central ones and the largest on the lateral slopes; these four smaller ones being a little depressed so as to form a shallow mesial sinus that is not continued to the beak. Crossing all of these plications of both valves, are numerous fine lines of growth; while the entire surface, as seen under a magnifier, is occupied by minute projecting points, like grains of sand; and, between these, a higher magnifying power shows the whole surface to be very minutely and regularly punctate.

"Length, 0.37 inch; breadth, 0.50 inch; convexity, 0.27 inch.

"Until the distinctions between the genus *Retzia* and the proposed genus *Trematospira* (if any exist) are better defined, and the interior of the species here described can be determined, it is not possible to say to which of these groups it most properly belongs.

"Specifically, however, it seems to be closely allied to *Trematospira gibbosa* of Hall, from the Hamilton group. Yet it differs, not only in having two to three more plications on each side, but also in having five instead of three a little raised to form the mesial fold of the dorsal valve (the middle one being also much smaller), and four depressed to form the mesial sinus (the middle two being much smaller than the others). It so nearly resembles the New York form, however, that I should almost be inclined to suspect that it might be only a variety of the same species, if it were not found at a so much lower horizon. It must be very rare, as I have only heard of the single typical specimen being found."—Meek, *loc. cit.*

Further description of this species is unnecessary. I have seen but a single undoubted specimen of this species. This is the specimen listed by me several years ago from the Eden shales at Vevay, Indiana.

RHYNCHOTREMA CAPAX (Conrad).

Plate XXXVI, figs. 6-6h.

Atrypa capax Conrad, 1842, Jour. Acad. Nat. Sci. Philadelphia, VIII, pt. II, p. 264, pl. xiv, fig. 21.

"Profoundly ventricose, with about twelve angular prominent ribs, transversely wrinkled, and four ribs on the mesial fold of the upper valve, which is wide, not profoundly elevated; inferior valve with a profound mesial fold, and very prominent ribs; greatest depth of the two valves nearly equal.

"*Locality.*—Richmond, Indiana, in Silurian shale."—Conrad, *loc. cit.*

Without figures, Conrad's original description would scarcely enable one to distinguish this species from numerous other Rhynchonellids. The presence of four plications on the fold and three in the sinus is an absolutely constant character. The ratio of height to length varies within very wide limits, young shells being always less gibbous than older ones. In fact, the nepionic and neanic shells ar very thin, the length being several times greater than the height. In very old (gerontic) shells, especially those found in the Whitewater division of the Richmond formation, the height may exceed the length by a considerable amount. The ratio of breadth to length is also subject to considerable variation, though not as much as the ratio of height to length. In old shells the beaks are closely incurved and appressed and encroached upon by the pedicle. The plications are strong and angular, and crossed by numerous closely arranged sharp lamellae of growth, especially conspicuous toward the front of the valves, giving to the shell a very characteristic appearance.

This is, besides *R. dentata,* the only Rhynchonellid in the Cincinnati group. Comparison between the two species is scarcely necessary, the single plication of the sinus of *R. dentata* alone sufficing to distinguish it from the present form. *Rhynchotrema capax* ranges from the base of the Liberty formation to the middle of the Whitewater division, except that it is found sparingly, if at all, in the Saluda in the southern part of the Indiana area. It has heretofore been supposed to range throughout the Richmond, but that this is a mistake is conclusively shown by recent careful collecting. It is especially characteristic of the Liberty division.

1.34A13, 14, 15, 16, 17, 18, 19, 19-21, 22....1.41A4, 5, 6, B3, C1, 2-3, D1, 2, 3, E4, 5, 6, 7....1.12D1-6, E3, F3. I have also collected this species near Bennington, Versailles, Osgood, Hamburg, Brookville, Laurel, Liberty and many other localities in Indiana, where the middle and upper parts of the Richmond formation are exposed.

RHYNCHOTREMA DENTATA Hall.

Plate XXXVI, figs. 7-7d.

Atrypa dentata Hall, 1847, Pal. N. Y., I, p. 148, pl. xxxiii, figs. 14a-c.

"Pyramidal, subtriangular; breadth somewhat greater than the length; cardinal line short; margins of the shell sloping abruptly downwards; surface marked by about eight or nine strong and deep plications, two of which are much elevated on the mesial fold of the ventral valve; dorsal valve with the sinus broad, deep and angular, with a single plication in the center, extremely elevated in front; plications crossed by zigzag or advancing and retreating filiform lines; beak of the dorsal valve small, acute, incurved, with no visible perforation. * * * "—Hall, *loc. cit.*

This species, while very constant in the number of plications on the valves, and absolutely constant, so far as I have observed, in the number of plications of the fold and sinus, nevertheless changes most remarkably, as the shell becomes older, in the convexity of the valves. In very old and gibbous individuals, the height may exceed the length of the shell, while in young individuals the height is only a small fraction of the length. The youngest stages seen (about 1 mm. in length) are decidely long and thin. Hall's description, together with the figures, will suffice for the identification of the shell, especially since there is no other with which it can be confused—*R. capax* having constantly four plications on the fold and three in the sinus. The chief interest of *R. dentata* is in the fact that it marks a well defined zone of the upper part of the Richmond formation, and is also narrowly restricted in distribution.

The best place to collect it is undoubtedly at Richmond, Indiana, where it is abundant in the Whitewater division, which it characterizes. South from Richmond I have seen the species at a horizon similar to that of its occurrence at Richmond, in the vicinity of Laurel, Indiana, and still farther south near Hamburg, Indiana. South of this point I have not seen the species except an occasional specimen at a horizon considerably lower. In the Tanner's Creek section I found two specimens at a level near the base of the Liberty formation (1.34A13a, 14a) and again on Whitaker's Branch in Dearborn County, near Moores Hill, at a similar horizon. In the latter place a single specimen was seen. At the higher horizon, only, and at Richmond and vicinity only, in Indiana, does the species run through any considerable thickness of rock. At all other localities and levels, in this State, the species is either rare or confined to a few inches or at the most a few feet of rock. No specimen, so far, has ever been found at Madison, Indiana.

This is another of the species of importance in working out the stratigraphy of the extreme upper part of the Richmond formation. Its associates in this connection are *Homotrypa wortheni, Monticulipora epidermata, Streptelasma divaricans, Homotrypella rustica,* and *Strophomena sulcata.*

1.34A13a, 14a....1.41A6, 7, 8, D3, E1, 2, 4, 5, 6, and in the vicinity of Laurel, Hamburg, and Moores Hill, Indiana.

SCHIZOCRANIA FILOSA Hall.

Plate XXXIV, figs. 8, 8a.

Orbicula ? filosa Hall, 1847, Pal. New York, I, p. 99, pl. xxx, figs. 9a-d.

"Orbicular; one valve more or less convex; apex marginal; surface radiated with numerous fine elevated thread-like striae, which are more or less prominent, depending on exfoliation of the shell; intermediate striae coming in between the others as they recede from the beak, but the striae are not bifurcate.

"It is with some hesitation that I refer this shell to the genus ORBICULA, since it presents same variation from the usual type. The young specimens are very convex, almost conical, but gradually become depressed and expanded as they increase in age and size.

"A single specimen, which is partially exfoliated, presents the marks of three visceral or muscular impressions, arranged somewhat like those of CRANIA; but since the shell differs as widely from types of that genus as it does from ORBICULA, I should scarcely feel authorized to place it under that genus, in the present state of our knowledge regarding it. The strongly striated surface presents a deviation from the general character of shells belonging to LINGULA or ORBICULA; but it is otherwise of the same texture—black and glossy, as those shells. It likewise occurs associated with them, proving that its habitat was similar, deviating no more from these genera than they do from each other.

"As the shell exfoliates, the surface becomes smoother, and the striae are nearly lost, except upon the margins."—Hall, *loc. cit.*

The types are from the upper part of the Trenton limestone at Middleville, New York. It is reported in Kindle's list from Madison, Indiana. I have not met with any specimens of it.

STROPHOMENA NEGLECTA (James).

Plate XXXVIII, figs. 1-1b.

Streptorhynchus neglecta James, 1881, The Paleontologist, No. 5, p. 4. (Not figured.)

"Shell resupinate; cardinal line longer than the greatest breadth of the shell farther forward, and more or less deflected at the extremities of different specimens; lateral margins sloping inward at first, then rounding regularly to the front. Cardinal line of the *dorsal* valve linear, straight and slightly projecting over the area of the other valve; umbone flat, slightly concave near the beak in most cases, more or less highly convex at the middle, of different examples, and curving abruptly to the lateral and front margins. Surface covered with crowded, radiating striae, which are fine and delicate at and just below the beak, becoming larger as they advance toward the margins, where they are rounded and strong; striae increased as the surface widens, by implantation, but not always of a uniform size; in some cases they vary considerably, and are irregularly arranged, from one to three or four of the smaller placed between two of the larger. Unworn examples show the whole surface covered with very fine, delicate, sharp, crowded, concentric, raised lines, crossing the radiating striae, which are distinctly seen under an ordinary magnifier. About ten of the radiating striae in the space of one line, at a quarter of an inch forward of the beak, and three or four near the free margins.

"*Ventral* valve: a strongly marked deltidium; cardinal area flat and moderately broad, sloping gently each way from the projecting beak, to the extremities of the lateral margins, and standing at an angle of 70 degrees or more with the dorsal valve; convex near the beak, and on the umbone; and different examples more or less deeply concave near the middle, curving, to correspond with the other valve, to the free margins. Surface of this valve covered with radiating striae and concentric lines, similar to the dorsal valve.

"The only feature of the *interior* of this species that can be referred to at this time is the deltoid process of the dorsal valve, which differs materially from specimens and figures of other species; it is prominent, stands at a high angle with the valve, is bi-lobed, each lobe divided by a deep, strong depression or slit, commencing at the beak and widening to the ends of the lobes.

"The breadth of the shell along the cardinal line, of different specimens, varies from 1½ to 2½ inches, and from 1 to over 1½ inches from beak to front. Other examples, supposed to be the young of this species, are much smaller. In outline and dimensions most of the specimens resemble some forms of *Strophomena alternata,* Conrad."—James, *loc. cit.*

Strophomena filitexta Meek (non Hall) is considered as a synonym of this species. The appearance of the interior of the dorsal valve of this species is thus described by Meek: "In the bottom of the valve three low, nearly parallel ridges start forward, from near the base of the cardinal process, the middle one of which is shortest, while the lateral extend to or a little beyond the middle of the valve. Two others also originate behind the middle, between these three, and extend forward parallel to each other, farther than any of the others. Between these four longer ridges three very slender much smaller raised lines may also somtimes be seen, while a large area of the central region of the valve, including the ridges mentioned, and a considerable space on each side of them, is occupied by small but distinct granulations, that show a tendency to arrange themselves in radiating lines."

The majority of the specimens of this species seen by the present writer have been the interiors of the dorsal valve, hence the foregoing description will, together with Meek's figures, prove of very considerable value in the identification of the species. I know of no other species with a similar set of internal characters.*

*Since the above was written I have received from Dr. Weller, the types of *Strophomena neglecta,* from the James collection. There are two specimens of somewhat different size and aspect, neither showing the interior of either valve. One of the specimens corresponds very well with the above description given by James. The other may not be the same species. Both are marked as coming from Cincinnati, although in view of the loose way of labeling material, formerly in vogue, this may not necessarily be taken very literally. I am quite convinced, however, that the larger specimen, which corresponds best with James' description, is

1.34A16, 17, 18, 19, 20, 21, 22....1.41A6, C1, 2-3, D1, 2, 3, E1, 2, 3, 4, 5, 6....1.12D1-6, F3.

STROPHOMENA NUTANS Meek.

Plate XXXVIII, figs. 5-5c.

Strophomena nutans Meek, 1874, Paleontology of Ohio, vol. I, p. 77, pl. vi, figs. 1 a-f.

"Shell under medium size, sub-trigonal, strongly concavo-convex, comparatively thick and strong; hinge about equalling the breadth of the valves; lateral margins usually somewhat straightened behind, where they meet the extremities of the hinge nearly at right angles, while anteriorly they converge to the middle of the front, which is prominent, and very narrowly rounded, or almost angular in outline.

"Dorsal valve remarkably convex in the central or anterior central region, from which it rounds down abruptly to the lateral and anterior margins, and slopes strongly posteriorly, the anterior lateral slopes being usually somewhat compressed, so as to impart to the middle of the anterior region a degree of prominence, somewhat like a mesial ridge, near the margin; whole umbonal region flattened; area narrow, or sublinear, and directed nearly backward; beak not distinct from the edge of the area. Interior with the bifid cardinal process short; sockets deep, sub-trigonal, and very oblique; socket-ridges rather prominent, thin, and continued obliquely forward and outward, with an inward curve, so as to form the lateral margins of the muscular impressions, which are well defined, rather deep, strongly striated, and separated by a short, mesial ridge coming from the base of the cardinal process; while near the middle of the anterior edge of each there is sometimes a little oblique prominence; central region in front of the muscular impressions, sometimes showing four obscure parallel

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not the same species as the specimen from which Meek drew up his description of the internal characters of the dorsal valve of his *S. filitexta*. In the set of types of the species *S. vetusta*, from the James collection, is a specimen showing the interior of a dorsal valve, which corresponds in every particular with the description of the dorsal valve of *S. filitexta*, given by Meek. This specimen, however, does not possess the wrinkles at the cardinal extremities that are supposed to characterize *S. vetusta*, and in other respects does not closely resemble the specimens of the type set in which the latter character is shown. If the dorsal interior, above mentioned, is really an interior of *S. vetusta*, which I very much doubt, then the specimens listed in the present report as *S. neglecta* James, are to be referred to *vetusta*, instead. The status of most of the species of *Strophomena* is at present in such an unsatisfactory condition, however, that I hesitate to make any changes from the ordinary usage, till such time as the genus can be revised with all the forms from all the horizons and localities at hand.

ridges running directly forward, and separated from each other by three shallow, narrow furrows, in the middle of each of which there is a raised line; traces of other smaller and more obscure ridges sometimes extend forward and laterally on each side of those described, while the whole internal surface is usually minutely granular.

"Ventral valve nearly flat, with a backward slope in the umbonal region, and distinctly concave farther forward, in the anterior central region; while the anterior and lateral margins are abruptly curved downward parallel to those of the other valve; beak scarcely distinct from the margin of the area, which is of moderate height, flat, and extends the entire length of the hinge, with usually but little taper toward the lateral extremities; foramen rather broad trigonal, and covered above by the convex pseudo-deltidium, which is broadly and deeply sinuous on its inner edge, for the reception of the cardinal process, and a kind of pseudo-deltidium of the other valve, formed by the continuation of the socket plates. Interior with the anterior and lateral margins geniculated so as to form a marginal ridge that is deeply and somewhat regularly furrowed across, while the ovarian spaces within this marginal ridge are more or less flattened, and sometimes granulated; hinge teeth moderately prominent, transversely sub-trigonal, and striated on their anterior and posterior faces; while from their inner bases the prominent dental ridges extend forward and curve together, so as to form a strongly elevated margin to the deep, sub-circular cavity for the reception of the muscular impressions; muscular cavity scarcely reaching the middle of the valve, usually with its rim slightly notched (not emarginated) at the middle of the front; while within its bottom it is provided with a slender mesial ridge, with the narrow adductor muscular scars on each side of it, and on the outside of these most of the remaining space seems to be occupied by the striated scars of the divaricator muscles, there being only a very small notch-like impression close to the hinge tooth on each side, apparently left by the ventral adjustor muscles.

"Surface of both valves ornamented by very fine, closely arranged, simple radiating striae, that increase by intercalation, and are either nearly equal, or sometimes have every third, fourth or fifth one slightly larger than those between; while on well preserved specimens, very minute, crowded, concentric striae may be seen, by the aid of a strong magnifier, crossing the much larger radiating striae.

"Length of a mature specimen, 0.80 inch; breadth, 0.93 inch; convexity, 0.50 inch."—Meek, *loc. cit.*

Mr. Meek cites his specimens from the "upper part of the Cincinnati group" in Butler, Warren and Clinton counties, Ohio. The species occurs in Indiana associated with *S. planumbona* in the Liberty formation.

STROPHOMENA PLANOCONVEXA Hall.

Plate XXXVIII, figs. 3-3e.

Leptaena planoconvexa Hall, 1847, Pal. New York, vol. I, p. 114, pl. xxxi B, figs. 7 a-d.

"Shell resupinate, sub-planoconvex, often distinctly inequilateral and oblique; ventral valve moderately convex; dorsal valve nearly flat or slightly concave; cardinal line extending considerably beyond the width of the shell, and often produced into small acute ears; surface marked by rather coarse radiating striae, which bifurcate towards the margin of the shell; apex usually, and perhaps always, perforated; foramen closed; cardinal area narrow.

"The most obvious characters of this shell are its resupinate form, the nearly flat dorsal valve, and frequent inequality of the two sides, or the greater extension of the cardinal line on one side. In these features alone it is dissimilar to all the other species of the genus in the lower strata. In its nearly flat valve it approaches to the ORTHIS; while the extension of the cardinal line, and closed foramen, are characters belonging to LEPTAENA, as well, also, as its general habit, which is different from the true ORTHIS.

"In some of its varieties, and particularly in the ventral valve being flat near the beak, it resembles the last species [*Leptaena deflecta*], but differs essentially from it in the coarser nearly equal striae and absence of concentric elevated lines, as well as other important characters."—Hall, *loc. cit.*

Reported by Hall from numerous localities in Ohio, Indiana, etc., in the Cincinnati series.

The terms dorsal and ventral are used by Hall in the opposite sense from their present usage.

1.34C14a.

STROPHOMENA PLANUMBONA Hall.

Plate XXXVIII, figs. 4-4d.

Leptaena planumbona Hall, 1847, Pal. New York, vol. I, p. 112, pl. xxxi B, figs. 4 a-e.

"Shell resupinate, robust, length and breadth as 9 to 11; cardinal line straight, suddenly deflected at the extremities, equal to or greater than the width of the shell; sides a little contracted just below the cardinal extremities, leaving slightly salient angles; ventral [dorsal] valve flat or slightly depressed near the beak, elevated and very convex in the middle, somewhat abruptly and concentrically deflected towards the margin; dorsal [ventral] valve flat on the disc, slightly elevated towards the beak, and deflected to correspond to the other valve; surface marked by radiating striae, every third, fourth or fifth of which is alternated by a stronger one; entire surface (in perfect specimens) marked by fine concentric elevated lines, and a few imbricating lines of growth.

"This is a very neat, symmetrical species, presenting very little variation of form. The concentric lines are often obliterated, and the surface shows only the radiating striae. The remarkable flatness, which often amounts almost to a depression of the convex valve near the beak, is a distinguishing character in all the specimens I have examined. The sides of the shell are suddenly constricted just below the extremities of the hinge line, producing small salient ears; the ventral [dorsal] valve is very convex just forward of the middle, and the opposite valve equally concave."—Hall, *loc. cit.*

It has become the custom to refer this species to *S. rugosa* of Rafinesque and de'Blainville, following a suggestion made by King in 1850, only three years after Hall's species was named. The most recent discussion on this subject that has come to my notice is a note on the species by Mr. J. M. Nickles, in the American Geologist (Oct. 1903). With the opinion of Nickles I quite agree. No one who has collected numbers of this species can look at the figures given by de'Blainville and believe that they were intended to represent the common *Strophomena planumbona.* They may or may not have been intended to represent *Leptaena rhomboidalis.* I believe, with Nickles, that we should go back to Hall's name, *planumbona,* and I have therefore quoted his as the original description rather than de'Blainville's.

This is a very common species in the Richmond formation, or rather in the division now known as the Liberty formation. This zone it characterizes better, perhaps, than any other species.

1.34A12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22....1.41A4, 5, B2, 3, C1, 2-3, D1, 2, E1, 3, 6....1.12D1-6, E3.

STROPHOMENA PLANUMBONA var. SUBTENTA Hall.

Plate XXXVIII, figs. 6-6g.

Leptaena subtenta Hall, 1847, Pal. New York, I. p. 115, pl. xxxi B, fig. 9a-b.

"Resupinate, semioval; ventral valve convex in the middle; cardinal extremities deflected, somewhat abruptly curving towards the margin, and flattened on the umbo; surface marked by fine equally bifurcating striae, which are crenulated by concentric lines, obliquely wrinkled on the cardinal margin; interior of the hinge showing two projecting tooth-like processes, with a narrow space between them for the passage of a ligament; lateral teeth spreading widely.

"I find, among the drawings of Mr. CONRAD, the figure of a Trenton species, with this name attached. I have not seen the same in New-York, but the specimen figured is from a western locality. It bears all the essential marks of the species cited, and I have therefore introduced it under that name. It will, doubtless, be found again in New-York. The cardinal margin bears some resemblance to CHAETETES, but a careful examination does not show any spires. The strong oblique wrinkles form a distinguishing feature."—Hall, *loc. cit.*

The localities given by Hall are Oxford, Ohio, where the species is said to be associated with *Dalmanella testudinaria* (probably *D. mecki*), *Rafinesquina alternata,* and *Plectambonites sericeus*; and at Trenton Falls, New York (doubtfully). This association would make the type come from about the base of the Liberty formation.

Schuchert considers this form a variety of *S. planumbona,* and with this I fully agree. In fact, I am almost prepared to go still further, and not even distinguish it as a variety. My observation leads me more and more to the conclusion that the oblique wrinkles seen on the cardinal extremities of species of *Strophomena* and *Rafinesquina* and related genera are due to slight causes (old age, especially) that affect occasional individuals rather than the species, or any considerable section of it. As to the differences in internal features, one will certainly despair if one tries to separate the two forms on this basis. The form figured by Meek (internal valve of his *S. plicata*) does indeed look quite different from the figure of the interior of the ventral valve of *S. planumbona* on the same plate. I have figured the ventral valve of another specimen, however, which might with almost equal propriety be referred to *S. planumbona, S. subtenta,* or *S. planoconvexa.* Why we should give such latitude to variations in *Rafinesquina alternata,* and so narrowly restrict them in *Strophomena,* is a question that must occur to any one familiar with the two genera. The tendency to call these forms of *Strophomena* species seems to me to be due more to caprice and accident than to anything in the relations of the forms to one another. I wish to take issue squarely with those who call every slight difference in form *specific.*

This variety occurs at the following localities:

1.34A13b, 15b, 17, 19, 21, 22....1.34A12....1.41D2....1.12F3.

STROPHOMENA SINUATA Meek.

Plate XXXVIII, figs. 2-2e.

Strophomena sinuata Meek, 1873, Pal. Ohio, I, p. 87, pl. v, figs. 5a-f.

"Shell semicircular, or forming rather more than a semicircle, moderately convex, with valves nearly equal, the dorsal being most convex in the central and anterior regions, and the ventral near the umbo; hinge nearly or quite equalling the greatest breadth; lateral margins forming more or less nearly right angles with the hinge line, or sometimes rounding to the same, and rounding regularly to the front, which forms a semicircular curve, with rarely a slight sinuosity at the middle.

"Dorsal valve flat at the beak, which is not distinct from the cardinal margin, usually a little raised in the middle at the front, so as to form a low, broad, undefined mesial prominence; cardinal area narrow and inclined backward; interior with a low, small, deeply bipartite cardinal process, from which diverge three small ridges, the two lateral of which extend obliquely outward to form the margins of the rather well defined sockets for the reception of the teeth of the other valve, while the third ridge is central, and extends a short distance forward; muscular scars not visible in any specimen examined.

"Ventral valve moderately convex at the umbo, which is not very prominent or arched, and has a minute perforation at the apex; front with usually a broad, shallow, undefined depression;

lateral regions more or less nearly flat; cardinal area well developed, tapering to the lateral extremities, flat, and inclined more or less obliquely backward; foramen closed by a prominent, triangular deltidium; interior showing small, somewhat saucer-shaped cavity, formed by the low, sharp dental laminae, extending forward from the inner side of the rather well-developed oblique cardinal teeth, and curving a little toward each other, without meeting at their inner ends; muscular scars not visible in any specimen examined.

"Surface of both valves ornamented with rather coarse radiating striae, most of which bifurcate once or oftener, while occasionally a shorter one is intercalated between two longer, crossing the whole, occasional small marks of growth, and finer, but obscure, concentric striae may be seen by the aid of a lens, on well preserved specimens.

"Length of a rather large specimen, 0.65 inch; breadth, 0.88 inch; convexity, 0.30 inch."—Meek, *loc. cit.*

The type is from the Cincinnati formation about 350 feet above low water of the Ohio, at Cincinnati, Ohio. I have seen it at a similar horizon near Manchester Station, on Tanner's Creek.

STROPHOMENA SULCATA (de Verneuil).

Plate XXXVI, figs. 10-10d.

Leptaena sulcata de Verneuil, 1848, Bull. Geol. Soc. France, 2d ser., vol. V, p. 350, pl. iv, fig. 4a, 4b.

"Coquille plate, subquadrangulaire, ornée de stries fines et dichotomes comme la précédente [*L. planoconvexa*]. Valve dorsale légèrement bombée, offrant vers le front un sinus pronocé qui relève le bord de la valve ventrale. Aréa triangulaire surbaissée. Ouverture large, fermée par un deltidium complet. Crochet percé d'un petit trou rond. Valve ventrale légèrement bombée; area presque nulle, présentant, vis-à-vis du deltidium de la valve opposée, une ferme toute communication du dedans au dehors. Malheureusement l'intérieur des valves nous est inconnu.

"*Rapports et différences.*—Extrêmement voisine de la précédente, cette espèce n'en diffère que par son contuor général et par le sinus de la valve dorsale. Ce sinus est constant, et la fait distinguer, dans la plupart de collections d'Amérique où nous l'avons vue, sous le nom que nous lui donnons ici.

"*Gisement et localités.*—Le *L. sulcata* se trouve avec l'espèce précédente dans le calcaire bleu des Etats d'Ohio et d'Indiana. Ce calcaire, comme celui de Trenton, appartient au système silurien inférieur.''—d'Verneuil, *loc. cit.*

This species is commonly found in association with *Rhynchotrema dentata,* but it also occurs sparingly at lower horizons, and its distribution is considerably more extended. I have never found it, however, except in the upper divisions of the Richmond formation.

In form this species is the most peculiar of any of the Strophomenas of the Cincinnati group, though it somewhat resembles *S. sinuata.* It is a small shell of semicircular outline, rather thicker than is usual in the genus, and with rather coarser plications. The convexity of the valves is nearly equal, but at the front the dorsal valve possesses a peculiar elevation or low fold, corresponding to a sinus in the ventral valve. The beaks are very small and the area of the dorsal valve narrow, while that of the ventral valve is well defined and rather high. Foramen with a convex deltidium. Apex perforated by a small circular aperture.

1.34A19-21, 23....1.41A7, 8, C1, D3, E1, 2....1.12D1-6. I have also collected it at Laurel, Indiana, and about Hamburg, and Osgood, not far from the top of the Saluda formation. This zone may represent the thinned southern end of the Whitewater division.

TREMATIS MILLEPUNCTATA Hall.

Plate XXXIV, figs. 9-9c.

Trematis millepunctata Hall, 1866, 24th Rep. New York State Museum (advance sheets), p. 221, pl. vii, figs. 22-25.

''Shell small, suborbicular, transverse on the ventral side and lenticular in profile. Ventral valve strongly convex below the middle, more depressed above; with a narrow deeply depressed pedicle-opening, the margins of which are flattened for a space nearly equal to the breadth of the opening. Dorsal valve more elongate, most convex above the middle; the beak pointed and projecting considerably beyond the opposite valve; with a depressed or concave triangular area. Interior of the dorsal valve marked near the middle by two comparatively large semicircular or reniform muscular scars, the breadth across the two more than equal to one-third of the diameter of the valve; the center of the valve has also a slight mesial septum.

''Surface strongly punctate in concentric curves passing from the center of the shell outwards, extending through the shell near the front of the valves, and distinctly marking the cast: inner layers of the shell not punctate.

"Specimens of this species have been sent from Cincinnati, and published and figured as the *T. terminalis* of Emmons. It differs from that species, however, in being more transverse, with a less convexity of the ventral valve and more prominent beak of the dorsal valve; and also in the character of the punctate structure. The Trenton species is distinctly punctured, the puncta passing through the shell, showing most distinctly on partially exfoliated specimens; while in this species they are entirely confined to the exterior layers of the shell. It is also destitute of the radiating striae always found on *T. terminalis* when the shell is partially exfoliated.

"The specimens of this species usually measure about half an inch in length and five-eighths of an inch in width. I have received them from Mr. S. P. Carley, Mr. U. P. James, and other sources."—Hall, *loc. cit.*

1.34A13a, 15b, 17.

TREMATIS RETICULARIS (Miller).

Plate XXXIV, fig. 10.

Crania reticularis Miller, 1875, Cincinnati Quarterly Journal of Science, vol. II, p. 280, fig. 22.

"Surface marked by punctures, arranged, as shown in the figure, in a peculiarly beautiful manner. The rows of punctures, from the cardinal margin, on each side the apex, curve downwards a little, as they ascend toward the apex. The rows as they leave the lateral margins form the same curves, so that the rows soon cross each other, giving the punctures the rhomboidal form, and the surface the checkered appearance, formed by curved lines gradually approaching and crossing each other, like 'engine turnings' on a watch-case.

"Length of a specimen, 0.08 inch; width, 0.11 inch; convexity, 0.04 inch.

"The specimen figured is one of a number found, attached by the lower or ventral valve to the under side of a worn piece of *Tetradium fibratum*, near Brookville, Indiana, by Mr. Ed. R. Quick, a collector of that place. The specimens vary in form considerably, but the punctate surface is as distinct and uniform as it is in *Trematis millepunctata*. The shell has the same appearance that the shells have in the latter genus, and it may be that it is a true *Trematis.*

"The acute apex and the variability of form, however, have induced me, at present, to class it with *Crania.* The lower valve and interior are unknown."—Miller, *loc. cit.*

ZYGOSPIRA CINCINNATIENSIS Meek.

Plate XXXVI, figs. 9-9b.

Zygospira cincinnatiensis Meek, 1873, Pal. Ohio, vol. I, p. 126, pl. xi, figs. 5 a-c.

"This variety or species differs from the last [*Z. modesta*], in its larger size, greater proportional breadth, more prominent mesial elevation, with a larger and deeper sulcus along its middle, and in the deeper mesial sinus of its dorsal valve, and the more spreading character of its lateral plications. Its plications likewise differ in being proportionally coarser, and more angular, and more frequently show a disposition to bifurcate, particularly those on the sides of the mesial elevation of the ventral valve, and within or near the mesial sinus of the dorsal valve. Its lateral margins are likewise generally more compressed; and the beak of its ventral valve rather more strongly incurved.

"Under a strong magnifier, in a favorable light, extremely minute, regular and closely crowded concentric striae may sometimes be seen on the sides of the plications, and other protected parts of the shell. These are similar to those sometimes seen on the last, but more distinct.

"Although this is possibly a distinct species from the last, it would, I should think, be rather difficult to distinguish young or small examples of it from that shell. Hence, I am inclined to think that it may be only a robust variety of the same.

"Length of one of the largest examples, 0.41 inch; breadth, 0.52 inch; convexity, 0.25 inch."—Meek, *loc. cit.*

This species occurs at a number of levels in the upper part of the Eden formation.

1.34C2, 5, 6, 7, 8, 9, 10, 11....5.9A29, 31, 35....1.38A17, 21, 24, 37, 45.

ZYGOSPIRA MODESTA Hall.

Plate XXXVI, figs. 8-8i.

Atrypa modesta Hall, 1847, Pal. New York, vol. I, p. 141, pl. xxxiii, fig. 15.

"Suborbicular or planoconvex, with the beak extended; width a little greater than the length; cardinal line distinctly marked and somewhat extended; dorsal valve convex, with an elevated ridge along the center, occupied by four plates which are stronger than the others; beak prominent, incurved and perforated, the perforation extending below the beak and occupying a portion of the area; ventral valve depressed-convex, broadly oval or nearly circular, with a broad but ill-defined sinus along the middle, the central plication stronger than the others, with a smaller one on each side; each valve with about 18 simple rounded plications; surface obscurely punctate.

"This neat and beautiful little species well merits the name bestowed upon it by Mr. SAY, which I am happy to preserve. It is a rare species in New-York, while it is abundant in Ohio, Indiana and Kentucky. It is, in a large number of specimens examined, very constant in the characters given above. The central elevated portion consists of four stronger plications, which appear to be in two pairs, from being separated in the middle by a deeper and wider groove, while the groove between each pair is narrower than between the other plates of the shell. These characters, with the stronger plication in the center of the ventral valve, are constant, and apparently reliable in distinguishing the shell. The mesial sinus on the ventral valve, which is scarcely conspicuous in young shells, becomes deeper and more strongly marked in older ones, and produces a strong depression in the front of the shell."—Hall, *loc. cit.*

No other species known to me from the Cincinnati series is as ubiquitous as the species described above. It occurs in the great majority of my collecting zones from the middle Eden to the top of the Cincinnati series. Even *Rafinesquina alternata,* with its varieties is not more persistently present than *Zygospira modesta.* Nor have I observed that the latter species presents any degree of variation. Certainly not enough to warrant an additional name. Though usually not particularly abundant, in several zones it becomes the leading fossil, occasionally completely filling the rock. This is the case especially in the Rafinesquina zone at several levels. In the Lorraine the species is usually common, and in washings from this formation, specimens of *Z. modesta* of all sizes from the nepionic stage, half a millimetre in diameter, to the adults, are so common that one almost tires of picking them out. In the Richmond formation it is usually less common, but nearly always present.

5.9A8, 25, 29, 31, 44, 50....1.33A3....1.34A1, 3, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, B1-3, 4-5, C5, 10, 11, 13, 14a, 14b....1.41A2, 4, 5, 6, 7, 8, 9, 10a, 10b, B1, 2, 3, C1, 2-3, D1, 2, 3, E2, 4, 5, 6....1.12A2, D1-6, E3, F3....1.38A11, 13, 17, 21, 23, 24, 29, 31, 32, 37, 41, 55, 63, Ba-h, and at practically all other localities.

GASTEROPODA AND PTEROPODA.

DIAGNOSES OF GENERA.

BELLEROPHON Montfort.

Symmetrically involute, subglobose shells, with or without an umbilicus, the latter never very large in the typical section; volutions more or less rounded on the back; aperture generally expanded, usually with a callosity on the inner lip; outer lip with a more or less deep emargination behind which there is a well developed slit-band or an elevated blunt keel; surface sculpture consisting of more or less strongly developed striae of growth only. (Ulrich.)

BUCANIA Hall.

Restricted by Ulrich.

Shell consisting of from three to five more or less depressed volutions coiled in one plane, with generally a wide umbilicus and not greatly—never abruptly—expanded aperture. Surface markings consisting of equal or unequal revolving riblets and lines of growth, together producing a more or less cancellated appearance. Revolving lines wavy or wrinkled, oblique, especially in the umbilicus, crossing from the ventral side of a whorl to the dorsal slit-band in the space of about one-half a volution. Frequently they are interrupted by strong lamellae, the wavy edges of which are parallel with the lines of growth and the apertural margin. Aperture transverse and somewhat reniform in the typical section, higher and relatively larger in the *B. nashvillensis* section. In the former the lips are thin, the outer one sinuate, and the sinus prolonged into a rather long narrow median slit; in the latter the lip is rather thick and the slit shorter. Slit-band distinct, raised or depressed. (Ulrich.)

CLATHROSPIRA Ulrich.

Shell depressed-conical, sometimes sublenticular; base more or less convex, its bulk usually nearly equal to the apical part; umbilicus very small or wanting; volutions not very numerous, sometimes slightly turriculate or strongly angular near the mid-height; aperture oblique, subquadrate, the inner lip slightly reflected or merely thickened, the outer deeply notched at the peripheral angle; no slit; band nearly vertical and situated upon the periphery of the whorls. The surface beautifully cancellated. (Ulrich.)

CONRADELLA Ulrich.

Shell coiled symmetrically, general form as in *Cyrtolites* and *Oxydiscus,* the volutions enlarging gradually and being strongly keeled dorsally. Aperture oval or subcordiform, widest in the middle or below, without callosities of any kind, nor with a sinus in the outer lip. From the aperture to a point about half around the dorsal circumference of the last volution there is a narrow open slit lying between two sharply elevated edges; behind this point the slit is closed over and forms an ordinary slit-band with distinct lunulae. Surface with close or distant transverse imbricating lamellae, the anterior edges of which are zigzagged and sometimes greatly spread out. Lamellae plicated, the successive folds often arranged so as to form small revolving ridges; over all very fine lines of growth. (Ulrich.)

CYCLONEMA Hall.

Shells turbinate or conical, thin, spire short, composed of few more or less ventricose volutions; no umbilicus; surface sculpture consisting of numerous revolving lines and small ridges crossed obliquely by sharp lines of growth; aperture oblique, varying from rounded to subquadrate; inner lip more or less thickened, reflected, always excavated. (Hall, Ulrich.)

CYCLORA Hall.

Subglobose, shell thin, spire short, consisting of a few whorls; columella smooth, slightly reflected over a minute umbilicus, aperture circular. (Hall.)

CYRTOLITES Conrad.

Shell coiled in the same plane, symmetrically or nearly so; volutions two or three, scarcely contiguous, the last occasionally free, enlarging gradually, carinated on the back and often on the sides, giving a subquadrate cross-section; aperture not abruptly expanding, with or without a median notch in the outer lip; no slit-band; shell thin, without callosities of any kind; surface sculpture reticulated or cancellated, consisting of straight or obliquely curved regular transverse lines connected by short oblique lines. (Ulrich.)

HOLOPEA Hall.

Shells conical, ventricose, more or less oblique or nearly direct; aperture round ovate; margin entire; surface marked by simple fine curved striae, or cancellated. (Hall.)

The above is Hall's original diagnosis of the genus. Ulrich thinks that the group formed by the species now referred to *Holopea* is composite and contains material for several genera.

HORMOTOMA Salter.

Shell elongate, beaded, practically imperforate, composed of rather numerous (eight to fourteen) rounded or subangular whorls; aperture acuminate subovate, narrow and more or less prolonged below; outer lip with a broad and deep V-shaped notch and no slit; band median or submedian, generally obscure, of moderate width, flat or slightly concave, in the perfect condition margined on each side by a delicate raised line; surface marked with lines of growth only; these are never very sharp and always sweep backward very strongly, from below especially, to the band. (Ulrich.)

HYOLITHES Eichwald.

Shell symmetrical, conico-pyramidal, composed of calcium carbonate, posterior portion often divided off by a transverse septum; one side flattened, and the margin of the flattened side projecting somewhat above the opposite wall. Surface with fine transverse striae, or longitudinally striated, or both.

CONULARIA Miller.

Shell rectilinear, inversely conical, rectangular to rhombic in cross-section, with usually sharp edges, acute or truncated posteriorly. Each of the transversely striated or ribbed lateral faces divided into longitudinal halves by a superficial groove, corresponding internally to a median ridge. Posterior portion of the shell divided off by septa. Aperture constricted by four triangular or linguiform incurved lobes of the anterior margin. (Pilsbry.)

LIOSPIRA Ulrich.

Shell sublenticular, the spire low, depressed conical, almost smooth, the sutures very close, scarcely distinguishable; volutions subrhomboidal in section, flat, gently convex or slightly concave above, sharply rounded at the periphery, convex below, and not infrequently angular at the edge of the umbilicus. The latter is usually present but may be filled entirely by an extension of the inner lip, in other cases it may be open during the younger stages only. Aperture deeply notched; band scarcely distinguishable as such, wide, situated on the narrow outer edge of the whorls though chiefly upon the upper side. Surface markings very delicate, rarely preserved, consisting generally of exceedingly fine transverse lines bending strongly backward on the apical side to the peripheral band over which they continue with little interruption to sweep sharply forward again on the lower side. Faint revolving lines occasionally observed. (Ulrich.)

LOPHOSPIRA Whitfield.

Shells with more or less elevated spires; whorls closely coiled throughout or only in the upper part, the last often exhibiting a tendency to become disconnected; whorls angular on the periphery and bearing from one to five distinct carinae; central or peripheral keel strongest and most prominent carrying the band, which is obtusely rounded, or more or less distinctly trilineate, with the median line heavier and more prominent than the other two; axis rarely, if ever, solid; an umbilicus, usually of very small size, nearly always present. Inner lip generally thickened, often slightly twisted, turning around the umbilicus so as to form a kind of hollow pillar. Outer lip more or less deeply notched, but the center of the notch, which lies at the peripheral angle, is never prolonged into a slit. Surface markings parallel with the apertural edge; occasionally cancellated by fine spiral lines. (Ulrich.)

MICROCERAS Hall.

Convolute, volutions few, horizontal, rapidly diminishing from the aperture; aperture subrhomboidal; shell subcarinated upon the back, chambered? (Hall.)

Minute shells, gregarious in habit, in form like *Cyrtolites*. Always of a black or brownish color, with the surface perfectly smooth and generally glossy. Possibly dwarfed varieties of other species. (Ulrich.)

OXYDISCUS Koken.

Strongly compressed, disciform shells; volutions embracing very little, expanding gradually to the aperture, sharply keeled; aperture somewhat lanceolate or subtriangular, without an inner callosity; outer lip with a deep V-shaped excision, continuing in the dorsal keel as a long and very narrow slit; behind the slit the summit of the keel may show a more or less distinct band with lunulae, or merely a delicately bordered raised line. Surface markings consisting of growth lines only. These bend strongly backward in passing from the ventral side of the whorl to the keel. (Ulrich.)

PROTOWARTHIA Ulrich.

Aperture large but not abruptly expanded, the outer lip bilobate, with a broad and more or less deep sinus but neither a slit nor band; dorsum convex, never carinate; umbilicus closed; surface markings very fine, generally consisting of more or less obscure crowded lines of growth and delicate revolving striae. The inner lip forms a thin granulose deposit over the dorsum of the inner end of the last whorl and extends on each side around the umbilical region. This portion is covered with interrupted or inosculating lines. (Ulrich.)

RAPHISTOMA Hall.

Shell sublenticular or plano-convex, the spire flat, the sutures close; volutions triangular in section, sharply angular and generally thin at the periphery; there is neither a slit nor a band; umbilicus varying in size but nearly always present; aperture turning backward slightly so as to form a shallow notch at the outer angle; lines of growth only; on the flattened upper surface these are slightly sigmoid and usually interrupted by a raised line between the two curves; passing over the acute edge they turn strongly forward and finally back again into the umbilicus. (Ulrich.)

SALPINGOSTOMA Roemer.

Shell symmetrically coiled in one plane; volutions numerous, enlarging gradually, scarcely ever embracing, the consequence being a large open umbilicus. Aperture abruptly expanded at maturity, trumpet-like; peristome thin, the outer portion slightly sinuate. Inner volutions with a slit band as in *Bucania*. This is replaced in the outer half of the last whorl by a long narrow opening or slit which, however, does not extend to the apertural expansion, but is closed some distance behind it. Surface marked with simple or sublamellose lines of growth and more or less oblique. irregular and sometimes interrupted or wavy revolving lines. (Ulrich.)

SCHIZOLOPHA Ulrich.

In every respect like *Lophospira* excepting that the apertural notch is prolonged into a long parallel-edged slit. (Ulrich.)

TROCHONEMA Salter.

Shell turbinate, umbilicated; spire varying in height, base generally flattened yet sometimes quite ventricose; whorls not numerous (4-8), varying from strongly angular to rounded, always with two more or less prominent ridges or angles between which lies a broad vertical, usually flat or concave, peripheral space; a third ridge usually near the suture, while a fourth usually surrounds the umbilical cavity. Other, but smaller ridges, may occur though chiefly on the basal half of the whorls. Lines of growth crossing the whorls from above obliquely backward, often vertical and not infrequently inclined in the opposite way on the peripheral band. In the last case the outer lip is broadly notched at the extremity of the upper peripheral angle. Aperture usually very oblique; peritreme complete; inner lip varying in thickness, not reflected. (Ulrich.)

TRYBLIDIUM Lindström.

Shell patelliform, obvoate, narrowest anteriorly, forming a very low cone; apex anterior, nearly marginal. Muscular scars in seven or eight disconnected pairs, arranged in an oblong circle, the anterior pair drawn out and meeting in front beneath the beak. Surface usually marked by concentric lines of growth only; occasionally also by obscure broad radial plications. (Ulrich.)

DESCRIPTION OF SPECIES.

BELLEROPHON GORBYI Miller.

Plate XXXIX, figs. 1-1b.

Bellerophon gorbyi Miller, 1891, Geol. Nat. Hist. Indiana, XVII, p. 694, pl. xiv, figs. 7-9.

"Shell medium size, involute, longer than wide. Volutions expanding very moderately, rounded over the dorsum, and subangular on the sides. Umbilicus deep, sides coverging with a slightly convex outline from the subangular sides. Mesial band or keel narrow, subangular. Aperture wider than high, subelliptical or reniform. Lip moderately thickened at the inner whorl, but not spreading, thinner on each side of the sinus in the outer margin. Surface beautifully sculptured and ornamented by numerous waving lines that curve forward from the mesial band on the dorsum and backward over the subangular sides, without interruption, and down the converging sides to the umbilicus.

"This is a beautiful species, and distinguished from all others, in rocks of the same age, by the reniform aperture, subangular sides and surface ornamentation.

"Found by Prof. S. S. Gorby, in the Hudson River group, in

Dearborn County, Indiana, and now in his collection. The specific name is in honor of the collector.''—Miller, *loc. cit.*

BELLEROPHON MOHRI Miller.

Plate XXXIX, figs. 2-2a.

Bellerophon mohri Miller, 1874, Cincinnati Quarterly Journal of Science, I, p. 306, fig. 30.

''Shell involute; outer volution abruptly expanded at the aperture, both in length and breadth; inner volutions comparatively small; dorsum angulated and strongly keeled; outer lip, rapidly expanding in a rounded outline upon each side of a shallow sinus, curving abruptly at the point of greatest expansion, and, with the inner lip, forming a line nearly at right angles with the plane of the volutions; inner lip thickened and bearing a prominent node in the middle; surface nearly smooth in the specimens examined, but faint traces of fine lines may be observed, curving with the shape of the shell downward from the sinus, at the outer edge of the expanded aperture.

''Aperture two inches in breadth, while the body whorl, just at the commencement of the expansion, is only one-half inch across it in the same direction.

''This species is remarkable for the strongly carinated dorsum, and for the great expansion of the aperture in proportion to the size of the inner whorls composing the body of the shell.

''The specific name is given in honor of Paul Mohr, Sr., of Cincinnati, an experienced and extensive collector of fossils and minerals, and member of the Cincinnati Society of Natural History.

''I found the species at Richmond, Indiana, in the upper part of the Cincinnati Group, associated with *Cypricardites hainesi.*''—Miller, *loc. cit.*

According to Ulrich, not uncommon in the upper part of the Richmond formation at Richmond, Indiana. (Whitewater?)

BELLEROPHON SUBANGULARIS Ulrich.

Plate XXXIX, figs. 3-3b.

Bellerophon subangularis Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 920, pl. lxiv, figs. 14-16.

''Having no umbilicus this species is related to *B. clausus* and *B. recurvus,* but it is distinguished at once from both by its subangular dorsum, and relatively narrower and somewhat triangular aperture. Its surface markings are rather distinct and regular;

on the dorsal slopes they sweep backward gently to the carina."—Ulrich, *loc. cit.*

The types are from the Richmond formation, Richmond, Indiana.

BUCANIA CRASSA Ulrich.

Plate XXXIX, figs. 4-4b.

Bucania crassa Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 893, pl. lxvii, figs. 46-48.

"This species, though closely resembling *B. frankfortensis* and *B. nashvillensis* in many respects, will be distinguished almost at a glance by its uniformly convex instead of subangular dorsum. This difference, in conjunction with a greater relative width of the whorls, causes the aperture to be proportionally wider. The lower lip also, though strong, has a longer slope and its surface is less convex. The umbilicus is somewhat smaller and more abrupt than in *B. frankfortensis,* and the shell is more globose.

"The specimen figured has suffered considerably from maceration, the slit-band and all, excepting the strongest of the surface markings, being quite obliterated. On two other specimens, neither as complete as the one illustrated, there is a low, yet well defined, rounded dorsal ridge, and in one this is accompanied on each side by a faint furrow, while anteriorly it terminates in an open slit about 17 mm. long. Whether this dorsal ridge was originally flat or concave on the summit, and bore lunulae, we are unable to say. Still it is to be expected that such a condition obtained on the perfect shell. As to the surface markings, what remains of them indicates a sculpture similar to that shown in our figures of *B. lindsleyi* and *B. nashvillensis.*

"The shell in this and the species with which we have compared it is unusually thick for the genus, especially on the ventral side of the volutions, and casts of the interior must look very different from the shells themselves. We have not, however, seen any casts which seemed at all likely to belong to either."—Ulrich, *loc. cit.*

The types are from the uppermost beds of the Richmond formation at Richmond, Indiana.

BUCANIA SIMULATRIX Ulrich.

Plate XLII, figs. 9, 9a.

Bucania simulatrix Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 892, pl. lxiii, figs. 48, 49; pl. lxvii, fig. 45.

"Shell large, known from casts of the interior only. These consist of three or four comparatively slender and loosely coiled volutions, leaving a large umbilicus in which all the inner whorls are clearly exposed. Volutions somewhat reniform in section, narrowly rounded in the ventral third of the sides, the ventral surface gently concave, the dorsal part of the section nearly semi-circular. Last volution obtusely carinated, with the dorso-ventral diameter increasing toward the aperture more rapidly than is the case with the inner volutions, the height and width of the whorl just behind the aperture being about equal, while at the smaller end the two dimensions are respectively about as three to five. Aperture somewhat triangular-ovate, wide below, the expansion taking place chiefly at the lower part of the sides. In the cast the expansion appears very abrupt, but doubtless it is much less so in the shell itself. Inner lips slightly reflexed at the sides, thick centrally; outer lip broadly and deeply sinuate. Surface markings unknown; slit long. The best specimen seen has the following dimensions: entire hight 46mm.; hight of aperture 29mm.; greatest width of same 33mm.; width and hight of last volution just behind the aperture about 23mm.; hight and width of inner end of same 5 and 8.5mm. respectively; greatest diameter of umbilicus about 23mm.; length of slit about 31mm.

"The hight in this species is relatively greater than in *B. frankfortensis,* which we consider as more closely related than any of the other species. The aperture also is less nearly triangular, the apertural margin as seen in a side view, less uniformly curved, the umbilicus larger, and the volutions more evenly rounded on the back. The next species, *B. crassa,* is a more closely coiled and heavier shell, having, therefore, also a smaller umbilicus. The form of the mouth and sinus is also different. Casts of *B. simulatrix* resemble those of the associated *Salpingostoma richmondensis* in a remarkable degree. For comparison see the description of that species." —Ulrich, *loc. cit.*

The types are from the Richmond formation, Richmond, Indiana.

CLATHROSPIRA SUBCONICA (Hall).

Plate XLI, figs. 8-8b.

Pleurotomaria subconica Hall, 1847, Pal. New York, I, p. 174, pl. xxxvii, figs. 8 a-e. Also p. 304, pl. lxxxiii, figs. 3 a-e.

"Trochiform; spire elevated, apex acute; volutions about five, flattened above, with a projecting carina just above the suture; last volution strongly carinated on the outer edge, and marked with a spiral band, ventricose below; aperture transverse, subquadrate, angular on the outer side and round below; surface marked by fine striae, which bend gently backwards from the suture, and more abruptly on the lower part of the whorl; spiral band a distinct groove, margined by sharp elevated edges, upon which the striae bend backwards in an abrupt curve; below this the striae bend gently forward, and thence curving backwards, terminate in the umbilicus; longitudinal striae crossed by transverse sharp elevated lines which are finer than the longitudinal ones.

"This is a beautiful trochiform shell, with a symmetrical conical spire, and beautifully cancellated surface. The finer concentric striae are often obliterated from wearing or maceration, the longitudinal ones only remaining, and these also are often obliterated. The spiral band is distinct on the last volution, and the striae upon it appear to be crowded into ridges. The suture is formed just at the lower margin of the band, leaving it visible at the lower edge of the higher volutions. In casts of this species, the outer angle of the last volution is distinctly carinated, as also the lower margin of the higher volutions."—Hall, *loc. cit.*

Occurs probably at many localities in Ohio and Indiana in the Lorraine and Richmond formations. According to Ulrich there is considerable doubt of the occurrence of this species in the Cincinnati region.

CONRADELLA DYERI (Hall).

Plate XXXIX, figs. 8-8c.

Cyrtolites dyeri Hall, 1871, 24th Report of the New York State Museum, 1872, p. 230, pl. viii, figs. 7, 8. (Advance sheet published in 1871.)

"Shell small, laterally compressed, consisting of two or more volutions, the outer one embracing the inner for about half its breadth, bearing a moderately wide umbilicus, in which may be seen a portion of the preceding volution; sides of the volution convex, obtusely subangular near the margin of the umbilicus into which it curves abruptly and more gradually declines with a slight convexity, toward the salient subcarinate dorsum. Transverse section cordiform, broadest near the umbilical margin.

"Surface of shell marked by from eight to twelve nearly equidistant revolving ridges, with sometimes smaller intermediate ones, and also crossed by numerous closely arranged transverse lamellose ridges having a double backward flexure between the revolving lines, and a general retral direction towards the keel of the shell.

"The species differs in its surface markings from any of the forms heretofore described."—Hall, *loc. cit.*

The character of the surface markings will make the identification of this pretty species an easy matter.

1.34A16b....1.12D1-6....1.12F3.

CONULARIA FORMOSA Miller and Dyer.

Plate XLII, fig. 2.

Conularia formosa Miller and Dyer, 1878, Jour. Cin. Soc. Nat. Hist., I, p. 38, pl. i, figs. 12, 12a.

"This species in general form is pyramidal, somewhat quadrangular, angles furrowed, and sides somewhat rounded as in *C. trentonensis.* The surface is marked by rounded furrows, separated by obliquely transverse ridges, extending from each angle of the shell diagonally towards the mouth, and meeting those from the opposite angle in the middle of each side. These ridges are ornamented with small nodes or tubercles at the junction with the striae, which cross the furrow on the side toward the apex of the shell. The rounded furrows are crossed by striae, which are about twice as numerous as the transverse ridges, and which terminate on the ridge toward the mouth of the shell in a small tubercle. The longitudinal striae do not cross the transverse ridges, nor are they continued in straight lines on the opposite sides (the magnified view is erroneous in this respect), but on the contrary the striae, which cross the furrows, commence at the ridge toward the apex, at a point between the tubercles, and crossing the furrow toward the mouth terminate at the tubercles.

"This species is readily distinguished from *C. trentonensis,* which it most resembles in general form, by the tubercles on the transverse ridges. Even badly exfoliated specimens may be distinguished by the aid of a pocket magnifier.

"The specimen illustrated is from the collection of C. B. Dyer, and was found in the upper part of the Cincinnati Group, near Versailles, Ind., by Dr. W. H. H. Hunter. Another specimen, showing very prominent tubercles, was collected by Dr. C. A. Miller, on the top of the hills near the city of Cincinnati, and is now in S. A. Miller's collection."—Miller and Dyer, *loc. cit.*

CYCLONEMA BILIX (Conrad).

Plate XL, figs. 2-2d.

Pleurotomaria bilix Conrad, 1842, Jour. Acad. Nat. Sci. Philadelphia, VIII, pt. II, p. 271, pl. 16, fig. 10.

"Spire conical; volutions four; sides subrectilinear at base, suddenly contracted at the suture; surface with spiral raised striae alternated in size; large volution abruptly rounded in its greatest circumference; base flattened and striated.

"*Locality.* Richmond, Indiana, in limestone of the age of the rocks of Salmon river series, New York. Lower Silurian.

"This species is the constant associate of PTERINEA *carinata,* in the limestone of the west, termed 'Cliff limestone.' This species of *Pterinea* is limited in New York to the Salmon river shales, and eminently characterises the formation."—Conrad, *loc. cit.*

This species, or rather forms supposed to belong to it, has been the cause of a good deal of confusion to collectors. We are indebted to Ulrich for a restriction of typical *C. bilix* to the Richmond group form, and the erection of a considerable number of new species, some of which are described elsewhere in this report. The differences between these forms are in most cases exceedingly slight, nevertheless they ordinarily have different ranges. Whether or not they should be considered as species or only good varieties may be left for discussion in some more appropriate place. I have taken my figure from Ulrich rather than Conrad, because the former is certainly better suited to illustrate the characters of the species.

1.34A10, 16a, 20, 21....1.41C2-3, D1, 3, E1, 2, 3.

CYCLONEMA BILIX var. FLUCTUATA (James).

Plate XL, figs. 3-3b.

Cyclonema fluctuata James, 1874, Cincinnati Quarterly Journal of Science, I, p. 152 (not figured).

"Shell turbinate, depressed; breadth greater than the length; volutions four or five increasing rapidly in size, the first one flattened on the under side; aperture suboval, oblique; suture broad and deep; inner lip thickened, outer lip thin and sharp. Surface marked by revolving lines, varying in size and distinctness, in some examples being sharp and prominent, in others scarcely visible to the naked eye, crossed by fine striae, or lines of growth, which, to the sharply defined ones, give the shell a beautifully ornamented appearance. Volutions with oblique undulations, and a broad revolving depression near or above the center, most conspicuous on the body whorls, sometimes extending to the apex.

"Height of a large specimen about 1¼ inches, breadth 1½ inches. Small ones less than ⅝ths of an inch in height and breadth."—James, *loc. cit.*

This form is considered as a variety of *C. bilix* by Ulrich. It is reported from the upper part of the Cincinnati group by James from several localities in Ohio and Indiana. Ulrich reports it in considerable abundance from Richmond and Versailles, Indiana.

CYCLONEMA HUMEROSUM Ulrich.

Plate XL, figs. 5-5c.

Cyclonema humerosum Ulrich, 1897, Geol. Nat. Hist. Minnesota, III, pt. II, p. 1061, pl. lxxviii, figs. 43-46.

"The average size in this species is somewhat greater than in either of the preceding forms, [*C. inflatum* and *C. varicosum*] while the apical angle is generally wider and more constant, the majority of the specimens varying comparatively but little either way from 85°. The principal feature, however, is a strongly developed shoulder, giving a deeper suture than in any other species of the genus. This shoulder may be rounded or, especially in the Richmond group form, quite angular. In the latter the slope of the outer side of the last whorl is very often distinctly concave, and not infrequently undulated in the direction of the lines of growth. The same conditions occur less frequently though quite as well marked in the Lorraine form. The surface markings are fairly constant. About ten principal subequal carinae occur on the outer slope of the body whorl, and about the same number of smaller ones on the periphery and base. The larger ones usually alternate with a much thinner set."—Ulrich, *loc. cit.*

Reported by Ulrich as very abundant in the upper half of the Lorraine group at Cincinnati, and not rare at several horizons in the Richmond group at Waynesville, Clarkesville, Oxford and other localities in Ohio, and at Richmond, Versailles and other points in Indiana. I have collected an abundant species or variety of *Cyclonema* in the Rafinesquina zone along Tanner's Creek since the new railroad cuts were opened there, that apparently is this species. This zone is not well represented in my Tanner's Creek section because, at the time, there were few exposures of these beds. At the present time they are completely and beautifully exposed in the cuts.

CYCLONEMA MEDIALE Ulrich.

Plate XL, figs. 4, 4a.

Cyclonema mediale Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 1059, pl. lxxviii, figs. 29, 30.

"Distinguished from *C. Bilix* Conrad, by its more ventricose whorls and stronger revolving carinae. The under side of the whorls is fuller and the outer side (seen in the spire) is always distinctly and uniformly convex, there being no sign of a shoulder at the suture, nor of the median concavity, both of which occur quite generally in Conrad's species. The suture is comparatively shallow. There are two common varieties, one having three widely separated strong carinae on the upper slope followed below by the smaller and gradually decreasing and crowding ridges or lines, the last occurring usually about the middle of the base. Much thinner revolving lines generally occur between the larger. In the other variety the revolving ridges are more equal in size and distribution, and at least three more in number. On the body whorl they number between fifteen and twenty, but not more than eight or ten of these show on the next whorl above, while in the first variety but four are shown. The apical angle for the whole shell varies greatly but always is narrower for the upper turns than it is for the last two or three.

"The strongly carinated variety resembles and probably was derived from *C. varicosum* Hall, but its whorls are less convex and the upper part of the spire more slender, the entire shell of *C. mediale* consisting of six or seven whorls, while *C. varicosum* probably never has more than five volutions. The columellar lip also is straighter and both the revolving and transverse ridges and lines stronger in Hall's species."—Ulrich, *loc. cit.*

This species of *Cyclonema* is, according to Ulrich, the common form in the lower part of the Lorraine formation of Ohio and Indiana. No doubt most collectors have been in the habit of identifying this form as *C. bilix*. The latter, as will be seen, is a Richmond form.

1.33A3, 1.34C14b, B1-3....1.38P.

CYCLORA MINUTA Hall.

Plate XL, figs. 6-6c.

Cyclora minuta Hall, 1845, Amer. Jour. Sci., XLVIII, p. 294. (Not figured.)

"Smooth; volutions about three, rapidly expanding towards the mouth; spire moderately elevated; aperture round and well defined. The last whorl forms the principal part of the shell.

"Height of shell 1-30 to 1-20 of an inch.

"This species is exceedingly numerous among those obtained by Mr. Carly, there being twice as many of this one as of all the others."—Hall, *loc. cit.*

There is still some doubt as to whether this and other minute species generally comprised under the name of *Cyclora* may not be the young of other species of Gastropods. They occur, however, in enormous numbers at horizons where other species are rare or lacking, a fact which admits of the interpretation that they are good species. It is also possible that all of these small shells are casts. The height of the spire and the form of the aperture seem to be the only characters in which this and the next species differ.

1.34A1, 7, 8, 9, 10, 11, B4-5, C13....1.12A2.

CYCLORA PARVULA Hall.

Turbo ? parvulus Hall, 1845, Amer. Jour. Sci., XLVIII, p. 294. (Not figured.)

"Spire elevated, volutions about four, smooth; first whorl angulated upon the centre towards the aperture; outer edge of the aperture projecting downwards.

"Height of shell 1/15 of an inch."—Hall, *loc. cit.*

Reported from Versailles, Indiana, in Kindle's list.

CYCLORA PULCELLA Miller.

Plate XL, figs. 7-7b.

Cyclora pulcella Miller, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 231, pl. ix, figs. 9-9b.

"Shell small, rather wider than high, whorls three, which increase rapidly in size, suture well defined, aperture somewhat circular, umbilicus moderately large. Surface ornamented with numerous fine lines, extending from the suture a little obliquely backward. The cast of this species bears a resemblance to *Cyclora minuta,* from which it is distinguished by its larger size and more rapidly swelling volutions. The shell is distinguished by these differences, and also by the surface ornamentation.

"Shell about a line in height, and about a line and a half wide.

"The author collected this species in the upper part of the Hudson River Group, near Versailles, Indiana."—Miller, *loc. cit.*

CYRTOLITES ORNATUS Conrad.

Plate XL, figs. 8, 8a.

Cyrtolites ornatus Conrad, 1838, Annual Report of the New York Geol. Surv. p. 118. (Not figured.)

"*Cyrtolites ornatus.*—Shell with transverse rounded ribs and fine striae; periphery acutely carinated. Length, 1 inch. *Locality,* Washingtonville, Oswego county [N. Y.]."—Conrad, *loc. cit.*

The following very excellent description is quoted from Ulrich and Scofield:

"Shell varying in diameter between 12 mm. and 30 mm., with the average at about 23 mm. Volutions two or three, rapidly increasing in size, strongly and sharply carinate dorsally, rhombic subquadrate in section; sides prominent and subangular or narrowly rounded along a line about three-fifths of the hight of the volution within the dorsal carina, the dorsal slopes gently convex and distinctly undulated by strong slightly curved transverse furrows and subangular ridges, the ventral or umbilical slopes almost flat and usually without undulations; ventral side with a sharp central furrow for the reception of the dorsal carina of the preceding volution. Umbilicus well defined, wide and deep, the edge wavy. Aperture a little wider than high, the height equalling usually a trifle more than half the greatest diameter of the shell, more or less rhombic-subquadrate, the outline often becoming a little rounded with age. Entire surface covered with a delicate network formed of raised lines running almost straight across the whorls and short connecting lines arranged alternately, the result being somewhat similar to the pitting of a thimble. In a good light the network is generally distinguishable without the aid of a magnifier, and, excepting three specimens, quite uniform in strength in different shells, there being on the outer half of the last whorl nearly always seven or eight of the transverse lines and eight or nine of the short lines in 2 mm. In the excepted specimens the network is more compact, there being over the outer part of the last whorl from ten to twelve of the transverse lines in the same space. On another, with the reticulation unusually coarse, the number averages between six or seven. On the last specimen a good magnifier brings out some very fine lines of growth running through the network. It is important to note that there is no perceptible backward curvature of the transverse lines in nearing and crossing the dorsal carina."—Ulrich and Scofield. Geol. Minn. vol. III, pt. II, p. 860.

Reported in Kindle's list from Versailles and Madison, Indiana. According to Ulrich it occurs in the Lorraine and Richmond.

HELICOTOMA MARGINATA Ulrich.

Plate XL, fig. 10.

Helicotoma marginata Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 1036, pl. lxxiv, fig. 39.

"Of this species we have seen but the unique example of which a view of the upper side is given on plate LXXIV [of Minn. Rept.]

It is remarkable chiefly because the lower part of the outer side of its whorls is so prominently developed that it projects like a broad flange."—Ulrich, *loc. cit.*

The type is from the extreme top of the Richmond formation at Elkhorn Falls near Richmond, Indiana.

HOLOPEA (?) HUBBARDI Miller.

Plate XL, figs. 11, 11a.

Holopea hubbardi Miller, 1893, Geol. Nat. Hist. Indiana, XVIII, p. 318, pl. ix, figs. 39, 40.

"Shell a little below medium size, depressed conical; width a little more than the height; whorls three, moderately and uniformly ventricose, the last one constituting nearly the entire shell, or four-fifths of it; suture moderately deep; aperture subcircular; umbilicus well defined; surface with close, fine striae, curving backward and indicating the growth of the shell.

"The size, shape of the mouth and umbilicus will distinguish this species from all others that have been defined.

"Found by J. F. Hammell and Prof. George C. Hubbard, in the Hudson River Group, at Madison, Indiana, and now in their collections and in mine. The specific name is in honor of Prof. George C. Hubbard, one of the collectors."—Miller, *loc. cit.*

HYOLITHES (?) DUBIUS Miller and Faber.

Plate XLII, fig. 3.

Hyolithes ? dubius Miller and Faber, 1894, Jour. Cin. Soc. Nat. Hist., XVII, p. 155, pl. viii, fig. 23.

"This is a very small species, rarely exceeding two-tenths of an inch in length. Transverse section circular. It increases very little in size from the commencement at an obtuse point. Sometimes it seems to be slightly curved. All the specimens are casts and very smooth. We are not sure that it is a *Hyolithes,* but if it is not it is quite anomalous, and deserves specific name. Fragments of Trilobites occur in the same association, but they are beautifully preserved, the tubercles on *Calymene* never appearing better; while this species is like *Hyolithes versaillesensis,* with which it is associated, and it would seem, therefore, impossible that it should represent the broken spines of trilobites.

"It is quite common in the upper part of the Hudson River Group, at Versailles, Indiana, associated with *Palaeoconcha faberi, cyclora pulcella, Hyolithes versaillesensis,* and other small fossils. It is in the collections of both authors."—Miller and Faber, *loc. cit.*

HYOLITHES VERSAILLESENSIS Miller and Faber.

Plate XLII, figs. 4, 4a.

Hyolithes versaillesensis Miller and Faber, 1894, Jour. Cin. Soc. Nat. Hist., XVII, p. 155, pl. viii, figs. 20-22.

"This is a small species, ordinarily about two-tenths of an inch in length, and never exceeding three-tenths of an inch in length. Transverse section subtrigonal, and sometimes one angle becomes so obtuse as to make a transverse section planoconvex. One side is always much wider than either of the others, and the angles adjacent thereto are usually much more acute than the other one. The broad side is slightly convex. The apex is sharp-pointed. All our specimens are casts and very smooth. While there are not many characters to ascribe to this species, nevertheless it is doubtless a *Hyolithes* quite different from anything hitherto described.

"It is quite common in the upper part of the Hudson River Group, at Versailles, Indiana, associated with *Palaeoconcha faberi, Cyclora pulcella,* and other small fossils. It is in the collections of both authors."—Miller and Faber, *loc. cit.*

LIOSPIRA VITRUVIA (Billings).

Plate XL, figs. 14-14b.

Pleurotomaria vitruvia Billings, 1865, Paleozoic Fossils, I, p. 171.

"*Description.*—Shell sub-lenticular; spire depressed conical, smooth; apical angle from 120° to 130°; whorls three. On the upper side the whorls make a nearly smooth flat slope from the apex to the margin, which is narrowly rounded, and shows some indications of a band. Below the margin convex, gradually increasing in prominence to the edge of the umbilicus which is rather sharply angulated. In the umbilicus the whorls are nearly flat and sometimes forming an indistinct staircase to the apex. The umbilicus is about one-third the whole width, abruptly ascending from the angulated edge to the apex. Surface nearly smooth.

"The whole of the aperture has not been observed, but several silicified fragments show that the inner lip is nearly straight and approaching the vertical, slightly convex in its upper, and concave in the lower half, giving an obscure sigmoid curve. It is much extended downwards, making the depth of the body whorl at the angle of the umbilicus at the aperture more than one-third the whole height of the shell.

"Width from 12 to 18 lines; height from 9 to 12 lines.

"This species is allied to both *P. americana* and *P. progne,* but differs from the former in having the whorls flat in the umbilicus instead of rounded, while the latter has the umbilicus closed.

"*Locality and formation.*—Paquette's Rapids, on the Ottawa River; Black River limestone."—Billings, *loc. cit.* Reported from Ohio and Indiana by Ulrich.

LOPHOSPIRA ACUMINATA Ulrich and Scofield.

Plate XL, fig. 15.

Lophospira acuminata (or var. of *L. perangulata*) Ulrich and Scofield, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 973, pl. lxxiii, fig. 8.

"Hight 10 mm. or less; apical angle about 42°. Volutions seven or eight, all contiguous; peripheral carina very prominent, trilineate, the central part of the band sharply angular; lower carina very strong, upper carina wanting; no umbilicus.

"Resembles and perhaps is merely a later variety of *L. perangulata* Hall, yet readily enough distinguished by its more depressed and more numerous volutions, especially considering that it is a smaller shell. It differs further in being relatively higher, the apical angle being narrower, in the greater prominence of the carinae, and in wanting the umbilicus which is so constantly present in Hall's species. A variety of *L. pulchella* is rather abundantly associated with this species at Spring Valley, Minnesota. It may be distinguished at once by its relatively stronger upper keel, *L. acuminata* being without this keel."—Ulrich and Schofield, *loc. cit.*

Reported by Ulrich from the Richmond group at Richmond, Indiana, and Blanchester, Ohio, and from near Spring Valley, Minnesota.

LOPHOSPIRA AMPLA Ulrich.

Plate XLI, figs. 1-1b.

Lophospira ampla Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 981, pl. lxxiii, figs. 52-54.

"Hight of Lorraine group specimens, 20 to 32 mm.; of Richmond group specimens, 22 to 50 mm.; apical angle 70° to 80°. Volutions about six, the last equalling about two-thirds of the total hight. Upper carina thick, near the suture, present on all volutions; lower carina nearly obsolete, represented by a broad swelling or low ridge, above which to the prominent peripheral band the surface is more or less concave. Inner lip very thick, almost or entirely covering the minute umbilicus, very broad and turned obliquely downward and forward in the basal half. Surface markings very strongly curved, unequal, on the whole not sharply defined.

"Closely related to *L. oweni,* yet easily distinguished by the greatly thickened, broad and obliquely extended inner lip. The apical angle also is greater, and the lines of growth are more curved, especially at the base, while the upper carina does not fade away on the last volutions as in that species. The presence of this carina distinguishes from the associated and otherwise similar *L. multigruma* Miller. *L. medialis,* which is usually much smaller, with the same number of volutions, a smaller apical angle and more distinct umbilicus, also has no such carina."—Ulrich, *loc. cit.*

This species is reported by Ulrich from the Lorraine formation at Cincinnati, Ohio, and at Covington, Kentucky; and from the Richmond group at Richmond, Indiana.

LOPHOSPIRA BICINCTA (Hall).

Plate XL, figs. 16-16b.

Murchisonia bicincta Hall, 1847, Pal. New York, I, p. 177, pl. xxxviii, figs. 5 a-h.

"Obliquely subconical; spire elevated, acute; volutions four or five, angular, rapidly enlarging towards the aperture; last one ventricose below, tricarinate, the lower carina hidden by the suture of the next volution at the upper inner angle of the aperture; central carina on the outer angle of the volution, margined on either side by a sharp elevated line, with a narrow groove between, producing a double spiral band; aperture oblong, angulated below; surface marked by fine sharp striae, which bend gently backwards, and are but slightly undulated in passing the first carina, from whence they turn more suddenly backwards to the mesial band, making an abrupt retral angle, and then bending forwards below, pass in a vertical direction to the suture. In the last volution the striae pass vertically to the lower slight carina which corresponds with the suture in the other volutions, and from thence bend slightly backwards, curving into the umbilicus.

"The minute description here given will be found perfectly applicable to entire and unworn specimens; but it is often found in fragments and casts, with the surface markings more or less obliterated. The double spiral band becomes obsolete, and only a single ridge is manifest; the lower carina on the last volution is not visible in casts, and there is but an obscure indication of the upper one. The entire casts, therefore, present scarcely more than the single marginal angle, indicating the direction of the mesial band, and, in this respect, correspond with *P. angulata* cited above; but the volutions in our shell are more ventricose.''—Hall, *loc. cit.*

So much confusion exists among collectors in regard to this species, or rather in regard to forms that are commonly supposed to belong to this species, that it seems to me advisable to quote at length the description by Ulrich given in the Paleontology of Minnesota.

''Volutions five or six, subangular; last one ventricose below, tricarinate, the upper ones bicarinate, the lower carina hidden by the suture; central or peripheral angle margined on either side by a sharp elevated line, with a narrow groove between, the angle, therefore, being composed of three lines of which the central one is a little stronger and more prominent than the lateral ones; lower carina thin, abruptly raised, the space between it and the peripheral angle scarcely concave and almost perpendicular; upper carina sharp, rather strong, removed a little more than a third of the biconcave upper slope of the volution from the suture; aperture somewhat obliquely subelliptical, higher than wide, narrow below, subangular at the lower inner corner; inner lip but little thickened, slightly twisted, never completely covering the minute umbilicus; outer lip very slightly sinuate. Surface marked by fine sharp subequal striae, curving backward very gently from the suture to the peripheral band; beneath the latter they pass in a vertical direction to the lower carina which scarcely interrupts their course to the umbilicus, near which only a slight backward curve is noticeable. On the most perfect specimen seen all the transverse lines present the appearance of being minutely papillose or toothed, while the central line of the peripheral band is crossed by straight lines of which there are nearly twice as many in a given space as those coming from above and below.

''The most marked and important feature of this species is in the exceeding shallowness of the sinus or notch in the outer lip.'' —Ulrich, Paleontology of Minnesota, 1897, p. 964.

As thus redefined and restricted, the species occurs in the Trenton rocks of Minnesota, Illinois and New York, Black River group of Kentucky, and Richmond group of Minnesota. It is reported in Kindle's list from Madison and Ripley County, Indiana; but in view of what has been said above it is doubtful if the species occurs at all in Indiana.

LOPHOSPIRA HAMMELI Miller.

Plate XLI, figs. 3-3a.

Murchisonia hammeli Miller, 1893, Geol. Nat. Hist. Indiana, XVIII, p. 319, pl. ix, figs. 41, 42.

"Species a little below medium size; conoidal; height one-third more than the breadth; volutions four or five; suture very indistinct; umbilicus closed. The body whorl bears two furrows, two sharply angular revolving ridges, and one less angular and fading away toward the mouth. Above the body whorl there are only two angular revolving ridges on each whorl. The aperture is partly formed by the last whorl; the inner lip is thickened, the outer one is thin. The aperture and revolving angular ridges will distinguish this species.

"Found by J. F. Hammel and Prof. Geo. C. Hubbard, in the Hudson River group, at Madison, Indiana. The specific name is in honor of one of the collectors."—Miller, *loc. cit.*

I have not seen the types of this species, but judging from the above description and Miller's rather poorly executed figure, it appears to belong to the genus *Lophospira.* It occurs at the extreme top of the Ordovicion (Saluda) at Madison, Indiana.

LOPHOSPIRA TROPIDOPHORA (Meek).

Plate XLI, figs. 2-2d.

Pleurotomaria (*Scalites?*) *tropidophora* Meek, 1872, Amer. Jour. Sci., 3d ser. IV, p. 278. (Not figured.)

"Shell rather small, obliquely rhombic in general outline, as seen in a side view; height somewhat greater than the breadth; spire conical, with an apical angle varying from 70° to 90°; volutions four to four and a half; each flattened, or sometimes slightly concave above, with an outward slope from the suture to a prominent angle that passes around the middle of the body-turn, and below the middle of those of the spire, to which it imparts a somewhat turreted appearance; suture moderately distinct, but not channeled; lower side of body-volution sloping rapidly inward from the mesial angle, a little below which there usually revolves an obscure, undefined ridge; aperture rhombic subquadrate; surface nearly smooth, but sometimes showing under a magnifier very obscure lines of growth, that curve very strongly backward as they approach the angle around the middle of the body-volution, both above and below—thus indicating the presence of a deep sinus i-the lip, that widens rapidly forward, though there is no defined revolving band at the angle.

"Length or height, 0.55 inch; breadth about 0.50 inch.

"This shell possesses some of the characters of both *Pleurotomaria* and *Scalites*. In general appearance it is most like some types of the former; but it seems to be entirely without the revolving band seen on the species of that genus. Its lines of growth, however, have the very strong, oblique backward curve seen in those of *Scalites* (in which group there is no revolving band), thus showing that its lip, when entire, must have had a deep notch at the termination of the angle of the body-whorl. This notch, however, does not appear to terminate in a deep sharply cut slit, as we most generally see in *Pleurotomaria,* but it seems to have terminated at, and widened rapidly forward from, the angle of the volutions. Specifically, this shell is related to *Pleurotomaria selecta* of Billings, from which it differs in having its striae of growth nearly obsolete, and in wanting the revolving angle just below the suture, seen in that species."—Meek, *loc. cit.*

Ulrich considers *L. multigruma* Miller sp. as a synonym of *L. tropidophora* Meek.

1.41E1, 5, A6.

MICROCERAS INORNATUS Hall.

Plate XL, figs. 9, 9a.

Microceras inornatus Hall, 1845, Amer. Jour. Sci., XLVIII, p. 294. (Not figured.)

"Volutions about two, rapidly diminishing; spire equally depressed on either side, obtusely carinated or angular upon the back; carina more conspicuous near the mouth, and gradually becoming obsolete; aperture somewhat quadrangular; surface smooth.

"Largest diameter 1/20 of an inch."—Hall, *loc. cit.*

There is little to be added in regard to this shell, which is chiefly characterized by its very small size, carinate volution, and smooth surface.

1.34A1, B1-3, C10.

OXYDISCUS MAGNUS (Miller).

Plate XLI, fig. 5.

Cyrtolites magnus Miller, 1878, Jour. Cin. Soc. Nat. Hist., I, p. 103, pl. iii, fig. 10.

"Shell consisting of three or more volutions, very gradually increasing in size and rolled in the same plane. Each outer volution embraces one-third or more of the inner one. Dorsal side sharp and well defined. Greatest convexity of each whorl near the inner side, which is sub-angular. Transverse section of a whorl sub-triangular. Umbilicus alike on either side, rather wide and deep, and showing about one-third of each inner turn.

"The surface of the shell, in the specimen examined, has been too much eroded to determine the external markings.

"The greatest diameter of the shell is 1 1/10th inches; convexity about 3/10ths of an inch, though it was probably more expanded at the aperture, which is not preserved in our specimen.

"The description is founded upon a single specimen collected by Mrs. Warren Shumard, in the upper part of the Cincinnati group, near Richmond, Indiana, and presented by her to Mrs. M. P. Haines, from whom it was received for definition and illustration."—Miller, *loc. cit.*

PROTOWARTHIA CANCELLATA (Hall).

Plate XXXIX, figs. 6-6b.

Bellerophon cancellatus Hall, 1847, Pal. New York, I, p. 307; pl. lxxxiii, figs. 10 a-c.

"Involute, subglobose; aperture expanded, bilobate; dorsal line subcarinated ?; surface cancellated by fine concentric and longtitudinal striae; concentric striae arching on the side and meeting in a sharp angle upon the dorsal line; aperture with a sinus in the dorsal margin.

"The concentric striae are usually the more conspicuous, the others being scarcely visible, except under a magnifier. The only entire specimen seen is crushed, so that the original form cannot be clearly defined; but the marking of the surface is sufficient to distinguish it from any other species in the lower strata."—Hall, *loc. cit.*

This is, according to Ulrich, the common form identified by Hall and other American authors as *Bellerophon bilobatus* Sowerby. The latter form probably does not occur in American faunas. The present form is said to occur in the Trenton, Utica, Lorraine and Richmond groups at numerous localities in Minnesota, Wisconsin, Iowa, Illinois, Kentucky, Ohio, Indiana, Tennessee, New York and Canada.

PROTOWARTHIA SUBCOMPRESSA Ulrich.

Plate XXXIX, figs. 5-5b.

Protowarthia subcompressa Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 873, pl. lxiii, figs. 40, 44.

"Shell, large, compressed-subglobose, the greatest hight and width about as six is to four; back broadly rounded, sides somewhat flattened, umbilicus closed, wanting; aperture semi-ovate, outer lip thin, inner lip moderately thick and reflexed in the umbilical regions; callosity extending over the whole front of the inner volution, apparently smooth; sinus broad and about as deep, the depth decreasing slightly with age; apertural lobes rounding very gently to the sinus where the outline makes a rather sharp curve. Surface marked by fine lines of growth and near the aperture by some obscure wrinkles. The callosity which extends over the inner volutions exhibits the usual fine irregular revolving lines in the umbilical regions. When the shell is removed, the cast shows a narrow furrow down the center of the back and several more faintly on each side. Greatest diameter 41 mm.; smallest diameter 29 mm.; width of aperture 27.5 mm.; hight of same (central) 19.5 mm.; width of inner volution 13 mm.; depth of sinus 7 or 8 mm.

"This fine species, besides attaining a greater size than *P. cancellata,* differs from it in being narrower and in wanting, as far as known, the delicate revolving lines of that species. The umbilical callosity of the inner lip is also less and does not slope outwardly, the edge only being reflected. *Bellerophon morrowensis* Miller and Dyer, which also may belong to *Protowarthia,* is sufficiently known. According to the descriptions, it seems to differ in having the dorsal side sharply angular. *P. planodorsata* has a wider aperture, revolving lines, and a flat dorsum."—Ulrich, *loc. cit.*

Versailles, Indiana, and Butler County, Ohio.

RAPHISTOMA RICHMONDENSE Ulrich.

Plate XLI, figs. 6-6b.

Raphistoma richmondense Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 941, pl. lxviii, figs. 7-9.

"Shell 15 to 20 mm. in diameter, the spire almost flat, the hight between one-third and two-sevenths of the width; volutions four, very slightly convex on the upper side, *i. e.,* within the outer edge, which forms a thin elevated rim; umbilicus very small in casts, apparently closed in shells. Surface striae fine and subequal on upper side, making the usual sigmoid curve, the change in curves occurring near the middle of the whorls. Just before reaching the peripheral rim the striae make another short backward turn. Beneath the periphery the striae are more unequal; at first they turn forward, then more directly inward.

"This species resembles the Chazy *R. calyx* Billings, but is smaller and relatively wider. In *R. crevieri,* of the same author and formation, the edge is blunter, and the lines of growth curve more strongly beneath it. *R. peracutum* has an umbilicus and differs in several other respects. A very similar species, differing only in that it has a small umbilicus, occurs in the Stones River group in Tennessee."—Ulrich, *loc. cit.*

The types are from Richmond, Indiana, where according to Ulrich good specimens are rare.

SALPINGOSTOMA EXPANSUM (Hall).

Plate XL, figs. 1-1b.

Bucania expansa Hall, 1847, Pal. New York, I, p. 186, pl. xl, figs 7 a-d.

"Convolute, trumpet shaped; volutions three or four, subangular, the last one elongated, rapidly enlarging and abruptly expanded at the aperture; aperture broadly semicircular or sublunate, with a sinus at the dorsal side; dorsal line obtusely carinated; section of the last volution, below the aperture, subtriangular; of the inner volutions, subelliptical, with the extremities obtusely angular; original surface striated. Specimen a cast.

"This shell is not unlike *Bellerophon cornuarietis* (Sowerby, *Min. Conchology,* tab. 469, fig. 2); but the volutions in that species are represented as not contiguous. The species under consideraiton differs from either of the two preceding in a very obvious manner. The broadly expanded aperture and obtuse carina of the last volution are prominent features; and in fragments the subtriangular form of sections of the last volution are often sufficient to enable us to identify the species. The strongly marked carina commences at the base of the last volution, and continues to the aperture. The volutions are closely pressed against each other, the convex dorsal side producing a corresponding depression on the ventral side of the contiguous volution."—Hall, *loc. cit.*

This is *not* a Cincinnati group species, but is so commonly reported by collectors from rocks of this region that it has seemed best to reproduce Hall's original figures and description. The species that is commonly mistaken for it according to Ulrich is the *S. richmondense.*

SALPINGOSTOMA RICHMONDENSE Ulrich.

Plate XXXIX, figs. 7, 7a.

Salpingostoma richmondense Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 903, pl. lxvii, figs. 39, 40.

"Shell slightly exceeding medium size, the hight, including apertural expansion, 50 to 55 mm.; known from casts of the interior chiefly. These consist of about three strong volutions, the inner ones wide, depressed, sharply rounded on the sides, broadly and evenly convex on the back, less convex and with a very slight central cavity on the ventral side, the whole giving a transversely elongate subelliptical cross-section, whose width is a little more than twice the hight. Dorso-ventral diameter of last volution increasing very rapidly in the outer half, while the transverse diameter enlarges very slowly. Just behind the apertural expansion, where the volution is more or less compressed laterally, the dimensions in three specimens (casts) are as follows: Width 22, 23 and 24 mm.; hight 26, 27 and 27 mm. At the opposite side of the shell the volution is about 15 mm. wide and 7 mm. high in all three specimens. The umbilicus is of the usual size for the inner volutions, but for the entire shell it is comparatively small. This is because the angular or narrowly rounded boundary moves gradually toward the ventral side of the volutions, causing the wall of the umbilicus to become more and more abrupt. Just behind the aperture it is nearly or quite perpendicular, the ventral surface of the volution being almost flat. Apertural expansion abrupt, apparently not very wide, with recurved edges, broadly ovate in outline, slightly narrower above than below. Dorsal slit about 20 mm. in length, beginning the same distance or somewhat more behind the apertural expansion. The slit is represented by a rough (fractured) ridge on casts. Behind it the cast is smooth, but in front of it there is a more or less distinct broad furrow.

"The surface markings have been observed only on the back of the second volution. Here they consist of about seven irregular revolving ribs on each side of a very narrow elevated slit-band. At intervals of about 1.5 mm. the ribs are interrupted by tranverse lamellae. Where they are shown the volution has a width of 7 mm.

"Collectors have heretofore identified this species with Hall's

Bucania expansa from the Trenton of New York, but a comparison proves it quite distinct. In the first place, though of about the same size, there is one volution less. Next, the last volution is relatively narrower and higher just behind the aperture, and the latter very differently outlined. Finally, the last volution is nowhere triangular as is the case in the Trenton species. Compared with *S. buelli* and *S. sculptilis* the outer volution will be found much larger especially as regards the dorso-ventral diameter.

"In practice the most difficult perhaps to separate from this species is the associated *Bucania simulatrix*. Though of widely different affinities, casts of these two species, especially when, as is usually the case, the aperture is imperfect, are very apt to be confused. Still, after familiarizing one's self with certain differences, they may be distinguished almost at a glance. In the first place, the volutions of the *Bucania* are more slender. This difference is particularly striking in an apertural view, the small end of the outer volution, in specimens of the same hight, being at least a fourth wider in the *Salpingostoma*. In the *Bucania* again the width of the last volution continues to increase quite uniformly instead of being almost constricted near the aperture. When the latter is preserved the difficulties have vanished, for this part is readily distinguishable."—Ulrich, *loc. cit.*

The types of this species are from Richmond, Indiana, from the Richmond formation. My specimens are all from the Whitewater division, occurring in association with *Rhynchotrema dentata.* It seems to be most abundant near the top of this division.

1.41A8, E1, 4.

SCHIZOLOPHA MOOREI Ulrich.

Plate XLI, figs. 7-7c.

Schizolopha moorei Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 992, pl. lxv, figs. 31-37.

"Hight of Richmond group form 28 to 38 mm., width 27 to 41 mm.; apical angle of same 75° to 82°; hight of Lorraine group form from 20 to 29 mm., width variable, usually about the same as the hight; apical angle 65° in one instance, 83° in another, usually about 75°. Of whorls there are at least six in the shell, but casts of the interior, in which form the species occurs almost invariably, rarely if ever preserve more than three or four, the first two or three having been filled with shelly matter. In casts it is only the last whorl that is strongly carinate on the periphery, the upper ones being more or less rounded. The umbilicus is variable, being as a rule relatively larger and less steep in the Richmond group form, which we regard as the typical one for the species, than it is in the Lorraine group variety. On the shell of the latter the edge of the narrow umbilicus is angular. That a similar angle surrounds the umbilicus in the typical form is doubtful, though we have seen no specimen showing this part of the shell. Very few casts give any idea whatever of the surface markings. As seen on gutta percha impressions of natural molds of the exterior, they appear as rather coarsely lamellose and strongly recurved lines of growth. The convexity of the slit-band seems to grow less with age, the elevated line on each side of it stronger.

"*Formation and locality.*—Lorraine group at numerous localities in the vicinity of Cincinnati, Ohio; reappears in the upper part of the Richmond group, of which it is one of the most characteristic fossils, at many localities in Indiana and Ohio, being perhaps the most abundant at Richmond in the former state and at Oxford in the latter."—Ulrich, *loc. cit.*

TROCHONEMA MADISONENSE Ulrich.

Plate XLII, figs. 1-1b.

Trochomena madisonense Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 1051, pl. lxxvii, figs. 23-25.

"A large shell agreeing in most particulars with *T. umbilicatum,* but having relatively higher and more ventricose whorls, while the ridge, which generally surrounds the umbilical depression in this genus, is quite obsolete. The shell is thicker, the surface markings stronger, the mouth very oblique and with thicker lips. Casts of the interior of the two species are more alike than their exteriors, yet those of the present may be distinguished by the greater separation of the whorls due to the removal of a greater thickness of shell. There is a wide notch in the outer and upper portions of the peritreme which, with the somewhat triangular form of the aperture in a ventral view, suggests relations with *T. eccentricum.* Figures of that shell are given on the same plate with those of this species, so that it is scarcely necessary to compare them further."—Ulrich, *loc. cit.*

The types are from the Richmond formation at Madison, Indiana.

TRYBLIDIUM INDIANENSE Miller.

Plate XXXIX, fig. 11.

Tryblidium indianense Miller, 1891, Geol. Nat. Hist. Indiana, XVII, p. 695, pl. xiv, fig. 14.

"Shell patelliform, oval, narrowed anteriorly, widened posteriorly; greatest width behind the median, transverse axis of the shell. Apex within the anterior third of the shell, moderately elevated. Greatest convexity of the shell immediately behind the apex. Shell sloping very gradually toward the posterior part of the shell and more abruptly in front of the apex, until it approaches the margin, where it graduates into a wide, very gently convex marginal slope, which in front becomes nearly flat. Surface of the shell, though not well preserved in our specimen, evidently concentrically lined, but if other ornamentation existed, it is wholly obliterated.

"The internal scars are unknown, but from external appearance of the shell, there is no reasonable doubt about the generic reference.

"Found by A. C. Benedict, in the Hudson River group, in Fayette County, Indiana, and now in his collection."—Miller, *loc. cit.*

TRYBLIDIUM MADISONENSE Miller.

Plate XXXIX, fig. 10.

Tryblidium madisonense Miller, 1893, Geol. Nat. Hist. Indiana, XVIII, p. 318, pl. ix, fig. 38.

"Shell medium size; apex high and almost straight above the anterior line of the shell; the shell slopes from the apex and arches a little toward the posterior part of the shell, but laterally and in front it descends abruptly to the margin; transverse section ovate; surface marked with fine, close, concentric lines and a few coarser ones, all of which appear to indicate lines of growth, instead of surface ornamentation; internal scars unknown.

"The high apex and anterior position of it seem to distinguish this species.

"Found by J. F. Hammel, in the Hudson River group, at Madison, Indiana, and now in his collection."—Miller, *loc. cit.*

PELECYPODA.

DIAGNOSES OF GENERA.

ALLONYCHIA Ulrich.

Shell attaining a large size, a little obliquely subovate in outline, strongly convex, most gibbous somewhat above and in front of the middle, but with the point of greatest convexity situated farther behind the anterior extremity than in any of the other genera of this family; beaks large, tumid, incurved, not terminal. Hinge line short, not alated posteriorly; just beneath the beaks a more or less well-defined, lobe-like protuberance of the anterior side contains the byssal opening and usually forms the most anterior part of the shell. Surface radially costate. Hinge short, apparently edentulous, ligamental area high; posterior adductor scar large, deeply sinuate above, situated somewhat behind the middle of the valves; pallial line simple, extending up the anterior side to the umbonal cavity. (Ulrich.)

ANOMALODONTA Miller.

Equivalve, inequilateral, byssal sinus on the anterior side, immediately below the beak, cardinal tooth or elevation beneath the umbone sloping posteriorly from the beak. Cartilage grooves running from the cardinal tooth beneath the beak to the termination of the wing posteriorly, and varying in number in the same species with the size and age of the shell, and having the same number of cartilage grooves on the anterior side of the cardinal tooth, that run together as they pass into the byssal sinus, immediately beneath the beak, which vary in number under the same circumstances. Adductor muscular impression on the anterior side, below the byssal sinus. The other muscular impression probably placed posteriorly on the wing. (Miller.)

Concerning this genus Ulrich makes the following comment:

"Dr. Miller is certainly in error when he says that there is an 'anterior muscular scar below the byssal sinus'. The depressed subtriangular space, which he mistook for a muscular impression, is without doubt due to some abnormal thickening of the internal surface of the valve. The pallial line also is clearly shown in the specimens."—(Ulrich, Geol. Ohio, VII, 1893.)

BYSSONYCHIA Ulrich.

General aspect as in *Ambonychia,* Hall, excepting that the beaks and umbones are not so full. A well-defined byssal opening in the upper half of the anterior side. Hinge with a striated ligamental area, several small cardinal teeth and generally two or three slender lateral teeth near the posterior extremity. Posterior adductor impressions large, situated a little behind the center of the valves. Pallial line simple, terminating in the rostral cavity. (Ulrich.)

CLIDOPHORUS Hall.

The shells of this genus may be characterized as equivalved, inequilateral; hinge without teeth or crenulations; surface (particularly in casts) marked by an oblique linear depression, extending from the anterior cardinal margin towards the base, indicating the place of the clavicle; surface concentrically striated. (Hall.)

CLIONYCHIA Ulrich.

Shells equivalve, moderately convex, subalate posteriorly; beaks terminal, comparatively small, not very prominent and but little incurved. Cardinal line straight, rather long, forming an angle of less than 90° with the anterior side. Surface marked concentrically only. No byssal opening, the margins closing tightly all around. Muscular impressions situated in the postero-cardinal third, large, bilobed, the lower lobe much larger than the upper. Pallial line simple, extending from the posterior adductor to the rostral cavity. Hinge plate of moderate strength, without cardinal or lateral teeth, excavated longitudinally for a linear ligament. Upper part of anterior edge thickened, producing a more or less well-marked impression in this part of casts of the interior. Anterior pedal muscle attached a short distance behind the beaks. (Ulrich.)

CTENODONTA Salter.

Shell equivalve, closed, usually largest anteriorly, occasionally subequilateral, with the beaks situated sometimes behind the middle, but usually more or less in front of that point; surface marked by concentric lines of growth; beaks approximate, generally small and never very prominent. Ligament external, rather small, situated immediately behind the beaks; no striated area nor internal cartilage pit. Hinge more or less arcuate, sometimes very gently, at other times bent almost at a right angle; with series of small curved or geniculated transverse teeth, which diminish in size more or less gradually from the extremities to the beaks; the series are continuous and gradually pass into each other in the typical section of the genus, but in other sections they are often interrupted beneath the beaks. Adductor muscular impressions two in each valve, subequal, nearly always readily distinguishable, and sometimes very deeply impressed, situated just beneath the anterior and posterior extremities of the hinge; scars of small foot-muscles have been observed in a number of species, one immediately above or in front of each of the adductor scars; pallial line indistinct, simple, submarginal. (Ulrich.)

CYMATONOTA Ulrich.

Elongate solen-like shells, gaping more or less at both ends, with the hinge line long and extending in a straight line anterior and posterior to the small beaks; ventral and dorsal margins subparallel. Hinge plate very thin, edentulous; valves united by a delicate linear external ligament seemingly extending the full length of the hinge. Test very thin, marked externally with fine concentric lines, and on each side of the hinge line short wave-like furrows. Pallial line and muscular scars so faintly marked that even in the best preserved specimens they can not be made out with certainty. (Ulrich.)

CYRTODONTA Billings.

Shell varying from transversely or obliquely ovate to subcircular, moderately ventricose. Beaks prominent, rather tumid, incurved, situated in the anterior third, fourth or fifth of the shell. Surface marked with concentric lines of growth. No lunule nor escutcheon. Hinge plate strong, nearly straight, often with a narrow and not sharply defined ligamental area. Cardinal teeth well developed, subequal, generally obliquely curved, sometimes nearly horizontal, two to four in each valve, situated mostly in front of the beaks. Posterior lateral teeth usually two or three in each valve, strong, elongate, more or less curved and slightly oblique, situated near the extremity of the hinge. Adductor muscular scars placed immediately beneath the two sets of teeth, both subovate, the posterior very faint, the anterior only moderately impressed. Pallial line simple. (Ulrich.)

ERIDONYCHIA Ulrich.

This genus includes, as far as known, a small and comparatively unimportant group of Lower Silurian shells, agreeing with *Bys-*

sonychia in all respects except that their hinges are entirely without cardinal and posterior lateral teeth. A well defined, striated ligamental area, however, is present, and in the type species several obscure and irregular small ridges beneath the posterior extremity of the external area remind of the internal ligament supports of *Anomalodonta*. But the oblique cardinal fold of the latter genus is not represented, and the acuminate beaks and oblique form of the shells gives them a peculiar expression, so that no other course seemed open than to erect a distinct group for their especial benefit. (Ulrich.)

ISCHYRODONTA Ulrich.

Short or moderately elongate, thick bivalve shells, having small, anteriorly situated beaks, with the hinge line straight or arcuate and extended posteriorly. Hinge plate wide and strong, without posterior lateral teeth, but with two strong cardinal teeth in the left valve, and one large one, and occasionally a small one on each side of it, in the right valve. Ligament internal, posterior to the beaks, linear, supported by from one to three subcardinal ribs. Anterior adductor impression large, deep, subovate, sharply defined on the inner and upper side by a ridge extending from the cardinal teeth to the base of the scar. A small pedal muscle was attached to the under side of the hinge plate immediately above the inner side of the anterior adductor scar. Posterior muscular scar faintly defined, generally but little larger than the anterior scar, situated a little distance beneath the posterior extremity of the hinge. Pallial line simple. Test thick, chiefly calcareous, without the dark epidermis of the *Modiolopsidae* and *Ambonychidae*. (Ulrich.)

MODIOLODON Ulrich.

Ovate shells of the same general type as *Modiolopsis* and *Modiomorpha,* but having from one to three oblique cardinal teeth in each valve. (Ulrich.)

MODIOLOPSIS Hall.

Restricted by Ulrich.

Shell more or less elongate, usually subovate, widest posteriorly; valves moderately ventricose, closing tightly all around. Beaks small, near the anterior extremity; umbones depressed by a flattening or depression which crosses the valves obliquely and widening causes a straightening or sinuation of the basal outline. Hinge of moderate strength, rarely straight, generally somewhat arcuate, without well-marked teeth; an obscure oblique thickening beneath the beak of one valve and a corresponding depression in the other occasionally distinguishable. Ligaments linear, external and internal, chiefly the former. Anterior adductor impression subovate, large, sharply defined on the inner side, occupying the greater part of the small anterior end. Posterior scar very faintly impressed, large, subcircular, situated near the center of the posterior third of the cardinal slope. Pallial line simple. Anterior pedal muscle forming a minute pit in the under side of the hinge plate beneath the beak. Posterior pedal muscles large, attached just above and in front of the adductor. (Ulrich.)

OPISTHOPTERA Meek.

Shell equivalve, usually triangular in outline, with the beaks of moderate size, incurved and terminal, and the hinge line straight and very long, in most cases forming a great posterior wing; length greater than the height; anterior side more or less abrupt. In the typical section the greatest height is in the anterior half, and the surface marked with numerous and frequently bifurcating costae. In another group of species provisionally regarded as congeneric, the posterior part of the shell is the highest, and the radiating costae few and mostly simple. Byssal opening, muscular scars and pallial line as in *Anomalodonta* and *Byssonychia*. Hinge with two small cardinal teeth in each valve, but so far as known no posterior lateral tooth; external ligamental area usually narrow; no internal ligament. (Ulrich.)

ORTHODESMA Hall and Whitfield.

Restricted by Ulrich.

Shell elongate, usually increasing slightly in height posteriorly. Anterior end comparatively long, contracted in front of the beaks. Valves moderately convex, usually with a strong umbonal ridge and a broad mesial depression in front of it, their edges fitting tightly along the straight or sinuate ventral margin, but leaving a narrow gape at each end. Umbones prominent, wide, compressed, often extending posteriorly as low cardinal ridges between which the hinge line is sunken. Hinge plate edentulous, very thin, long, extending in almost a straight line from the posterior cardinal angle, past the beaks, nearly to the anterior extremity of the shell. Ligament linear, internal and external, the latter chiefly. Posterior muscular scar large, very faint, elongate ovate; anterior scar large, though scarcely half the size of the posterior, well defined, ovate or approaching semicircular in shape, the vertical diameter the longest. Pallial line simple. Shells thin, marked externally with more or less distinct concentric striae and wrinkles. (Ulrich.)

ORTHODONTISCUS Meek.

Shells rather small, rounded or ovate, subequilateral; valves equal, moderately convex, with small beaks and no umbonal ridge. Surface marked with very fine concentric lines and occasionally with obscure rays on the post-cardinal slope. External ligament occupying a narrow groove extending both anterior and posterior to the beaks. Hinge with one strongly defined, subtriangular cardinal tooth beneath the beak of the right valve, with a small pit just in front of it and a corresponding large pit and a small tooth in the left valve. Posterior lateral teeth long, two in the left valve and one, two or three in the right. Anterior lateral teeth similar to the posterior laterals only shorter. The large cardinal tooth (in the right valve) is usually divided into three radially disposed portions. Pallial line simple, muscular impressions well defined, though not deep, the posterior slightly the larger, both with a small pedal muscle scar above and occupying the small spaces between the adductor scars and the opposite extremities of the two sets of lateral teeth. (Ulrich, diagnosis of *Cycloconcha*=*Anodontopsis*.)

ORTONELLA Ulrich.

Shell subquadrate, highest posteriorly, equivalve, very inequilateral, with moderately prominent beaks and umbonal ridge. Surface with concentric lines of growth. Hinge as in *Cyrtodonta,* Billings, excepting that the cardinal teeth are relatively stronger and placed immediately beneath the beaks. A well defined lunule and escutcheon present. Adductor muscular scars subequal, the posterior one very faintly impressed, ovate, and situated just beneath the posterior extremities of the lateral teeth, the anterior very deep, sharply defined on the inner and upper sides by a clavicular ridge extending obliquely backward from the hinge plate. Pallial line simple, distinct. Small pedal muscle attached to the under side of the hinge plate immediately over the anterior adductor scar. Casts of the interior marked by an oblique umbonal sulcus. (Ulrich.)

PTERINEA Goldfuss.

Shell equivalve, inequilateral, with both sides alate, the anterior alation short and the posterior drawn out. Cardinal margin more or less oblique, internal ligamental area linear. Two or more parallel teeth beneath the umbo, and several long posterior teeth. Umbones anterior. Two large muscular impressions. (Goldfuss—translation.)

The valves are *inequivalve,* the right valve being flat, or nearly so. The anterior teeth obscure, transverse; the posterior elongate and nearly parallel to the cardinal margin. Posterior adductor scar large; anterior small, strong, inserted below the anterior wing. Pallial line simple. Byssal notch in the smaller valve.

RHITIMYA Ulrich.

Shell elongate, moderately ventricose, the dorsal and ventral margins subparallel, gaping slightly at one or both ends. Beaks rather prominent, situated from one-third to one-fifth of the entire length behind the anterior extremity; posterior umbonal ridge rounded, never very prominent; mesial sulcus very wide, generally very shallow, often, however, causing a sinuosity in the ventral margin. Lunule very narrow, true escutcheon wanting, ligament external, attached to the edges of the valves, extending the greater part of the hinge line posterior to the beaks. Hinge apparently edentulous, test very thin. Muscular and pallial attachments exceedingly faint, not satisfactorily observed; posterior scar large. Surface marked with unequal concentric lines and furrows, gathered into a series of strong folds on the anterior end. On the posterior half or more, the ventral part especially, the concentric lines are crossed by closely arranged radiating series of small granules or spines. (Ulrich.)

SEDGWICKIA McCoy.

This genus was founded by McCoy on Carboniferous species. It is very doubtful if the Ordovician forms referred to this genus belong there.

SPHENOLEUM Miller.

Shell large, equivalve, inequilateral, elongate, cuneiform, ventricose; umbones prominent; beaks incurved at the anterior end; cardinal line at an angle of fifty or sixty degrees from the basal line, and appearing wing-like toward the posterior end; lunule present; no escutcheon; ligament external; muscular scars and hinge-line unknown. (Miller.)

Surface concentrically lined; occasionally with radiating striae. Ligament probably both internal and external. (Ulrich.)

WHITEAVESIA Ulrich.

Shell ovate, more or less elongate, narrowing anteriorly. Valves moderately ventricose, fitting each other tightly. Anterior end short, but not excessively so. Base gently convex, occasionally straight, never sinuate. Mesial sulcus wanting. Beaks comparatively large, full and rather prominent. Umbonal ridge generally strongly rounded, sometimes subangular. Surface with concentric lines of growth and often with radii or divaricating folds; the radii sometimes restricted to the inner side of the shell, showing on casts of the interior and not on the exterior of the shell itself. Muscular scars and pallial line as in *Modiolopsis*, excepting that in the majority of the species they are very faintly impressed. Hinge plate edentulous, very narrow, especially so under the beaks, a little wider and grooved on each side for the reception of a linear internal ligament. A similar external ligament probably also present. (Ulrich.)

WHITELLA Ulrich.

Shell thin, obliquely quadrangular or suboval, equivalve, inequilateral, more or less ventricose. Umbones very prominent, the beaks strongly incurved; umbonal ridge prominent, subangular or sharply rounded. Cardinal margin straight or slightly convex, the edges inflected to form a sharply defined escutcheon extending beyond the beaks sometimes quite to the anterior extremity of the shell; area finely striated longitudinally. Hinge line straight, from one-half to two-thirds the length of the shell, with two to five rather oblique folds or teeth in front of the beaks. Posterior portion of the hinge apparently edentulous. Ligament probably both external and internal, the latter only along the posterior third of the hinge line, where it was supported by an internal ridge in each valve. Two simple adductor impressions, the posterior one very faint; pallial line simple, marginal; interior of shell lined with a nacrous film. Surface of shell with fine concentric lines, and sometimes with stronger concentric undulations. (Ulrich.)

DESCRIPTION OF SPECIES.

ALLONYCHIA JAMESI (Meek).

Plate XLIII, fig. 2.

Megambonia jamesi Meek, 1872, Proc. Acad. Nat. Sci. Phila., 1872 (February), p. 321. (Not figured.)

"Shell attaining a rather large size, a little obliquely subovate in general form, rather convex, the most gibbous part being somewhat above and in front of the middle, more or less abruptly cuneate posteriorly and below; basal outline regularly rounded; posterior margin rounding into the base, and ascending with a convex curve and forward inclination to the posterior extremity of the hinge, which is not in the slightest degree alate; anterior margin rounding into the base below, and slightly sinuous under the lobe-like protuberance, or rudimentary wing above, which is convex. slightly more prominent than the margin below, and defined from the swell of the umbonal regions on each side, by an oblique sulcus extending to the hinge margin in front of each beak; hinge equaling about two-thirds of the antero-posterior diameter of the valves; beaks rather prominent, or rising distinctly above the hinge line, but slightly oblique, and distinctly incurved; umbonal slopes broadly rounded; longer axis of the valves moderately oblique to the hinge line. Surface ornamented by very regular, rounded, simple, and depressed radiating costae, a little wider than the furrows between, and numbering about five in a space of 0.30 inch, near the middle of the lower margin.

"Height, about 2.05 inches; antero-posterior diameter, 2.16 inches; convexity, 1.50 inch.

"The only specimen of this species I have seen is a cast of the exterior, with portions of the ventral and anterior ventral margins broken away. The beak of its right valve projects rather decidedly above that of the left; but I think this is due to accidental displacement of the valves, rather than to any inequality in their size. It shows distinct indications of a well-defined, moderately wide cardinal area, widest under the beaks, and narrowing to the extremities of the hinge.

"Mr. James referred this species, in his list of the Cincinnati fossils, with a mark of doubt, to the Lower Helderberg species, *M. spinneri* of Hall. But, in addition to the rather widely different geological horizons from which these two shells were obtained, they seem to me to differ so materially in form as to be clearly distinct species, even if similarly marked, while the typical specimen of *M. spinneri* shows no traces of the regular radiating costae seen on the species here described. It is true that the specimen of that species figured is an internal cast, and ours a cast of the exterior, which might account for the difference of surface characters, but this would not produce the degree of difference in form, obliquity and general physiognomy. To me, it appears to be much more nearly like the typical species *M. cardiiformis*, from the New York Upper Helderberg limestone, though clearly distinct in having much larger costae as well as a wider and more defined cardinal area."—Meek, *loc. cit.*

Identified from the Lorraine at Lawrenceburg, Indiana.

1.33A3.

ANOMALODONTA COSTATA Meek.

Plate XLII, figs. 6, 6a.

Ambonychia costata Meek, 1874, Paleontology of Ohio, vol. I, p. 130, Pl. xii, figs. 5 a-c. Named but not described by James, 1871, Catalogue of the Lower Silurian Fossils of the Cincinnati Group, p. 13.

"Shell of about medium size, moderately oblique, sub-ovate, very thin, rather compressed, the left valve being apparently a little more convex than the other; basal margin regularly rounded; posterior margin apparently broadly convex in outline; anterior side truncated, or a little concave above, and rounding into the base below; beaks pointed terminal, rather oblique, and rising moderately above the cardinal margin; umbonal slopes not angular, or very prominent; hinge line straight, short, and ranging at an angle of about 60° to the longer axis of the valves. Surface of both valves ornamented by about twenty simple depressed, radiating costae (narrower than the flat interspaces) and fine concentric striae of growth.

"Length, measuring obliquely from the points of the beaks to the most prominent part of the basal margin, about 1.63 inches; anterio-posterior diameter, about 1.10 inches; convexity of the two valves, 0.54 inch.

"This form will be readily distinguished from the other known species by its small number, and more widely separated costae, and rather compressed, narrow form. It also differs from *A. radiata* [*Byssonychia radiata*], in having its costae separated by flat interspaces, instead of 'regularly concave grooves, narrower than the radii.' "—Meek, *loc. cit.*

The types are from 350 feet above low water of the Ohio river at Cincinnati, Ohio.

1.34C14b.

ANOMALODONTA GIGANTEA Miller.

Plate XLIII, figs. 1-1b.

Anomalodonta gigantea Miller, 1874, Cincinnati Quarterly Journal of Science, I, p. 17, figs. 7, 8, 9.

"Shell equivalve, inequilateral, alate posteriorly and compressed, more convex toward the umbones and anterior side, anterior side abruptly declining, beaks rather sharp and slightly incurved. Surface marked by 30 to 40 strong radii, same width as intermediate spaces, which are concave grooves marked with concentric striae, giving much the same external appearance as those of an *Ambonychia radiata.* Shell marked exteriorly, toward the margin, with lines of growth and concentric striae, which cross the radii, rendering it likely that concentric striae crossed the radii over the whole surface of the shell, though they appear now to be smooth. Byssal sinus immediately below the beak anteriorly, about 1/4 of an inch in diameter in a large specimen. Height of the shell from 2 to 4 inches, greatest breadth about 1/5 less. Shell quite thick about the umbones and wing, but thinner toward the base. Large cardinal tooth or elevation beneath the umbones, and sloping posteriorly from the beak. The cardinal elevation on the left valve having a depression to receive a corresponding elevation, though slight, on the right valve. From the cardinal tooth there are from 4 to 18 lateral cartilage grooves extending posteriorly to the end of the wing, and terminating with the shell, and there are the same number of cartilage grooves on the anterior side of the cardinal tooth that immediately run together as they pass into the byssal sinus. The cartilage grooves vary in number with the age and size of the shell. The shell is thickened on the anterior side, and appears to show lines of growth passing through the sinus to its base. A large muscular impression is found near the anterior margin, half way from the sinus to the base of the shell, and there are appearances that indicate another muscular impression on the posterior wing of the shell, near its termination. Greatest depth of a valve in a large specimen, 1/2 an inch.

"This is the largest bivalve yet known in the Cincinnati Group. It may readily be distinguished from the *Anomalodonta alata* by the surface markings, though the general outline form of the two shells are nearly the same.

"I found this species near Versailles, Indiana, about 40 miles west of Cincinnati, and about 300 feet below the Upper Silurian rocks; and I also found what I believe to be a cast of the same at Richmond, Indiana. I do not know that it can be found elsewhere, but the probabilities are that it can be found in the upper part of the Cincinnati Group, from Madison to Richmond, and at other places."—Miller, *loc. cit.*

Miller's specimens evidently came from somewhere in the Waynesville formation. They could not have come from as low as 300 feet below the Silurian, and have come from Versailles at all, since the total thickness of the Versailles section is only about 170 feet.

Concerning this species Mr. Ulrich, who has given it very careful study, has this to say:

"Dr. Miller is certainly in error when he says that there is 'an anterior muscular scar below the byssal sinus.' The depressed triangular space which he mistook for a muscular inpression is without doubt due to some abnormal thickening of the internal surface of the valve. Nothing of the kind has been observed in any other of the numerous specimens observed by me, while the true position of the large muscular scar, which was left by the posterior adductor, and not the anterior, is unequivocally shown in several cases. The pallial line also is clearly shown in the specimens, and as it runs through the space to which the muscle was supposed to have been attached and on to the cavity of the beak, it affords the very best evidence in favor of the view here adopted." (Ulrich, Geol. Ohio, vol. VII, 1893, p. 637.)

1.34A3, 10....1.41A6, 7, D2, E2, 4....1.12E3.

BYSSONYCHIA ALVEOLATA Ulrich.

Plate XLII, figs. 7, 7a.

Byssonychia alveolata Ulrich, 1893, Geol. Ohio, VII, p. 631, pl. xlviii, figs. 1-3.

"Shell of medium size, moderately convex, obliquely acuminate-ovate, wider than usual, with the basal half of the outline semicircular; cardinal margin somewhat shorter than the middle length of the shell; umbones full, beaks but little incurved, separated; ligamental area very large; beneath the beaks the anterior side is impressed, forming an obscurely defined subcordate lunule, in the lower part of which the byssal opening is situated. Surface marked by about fifty rounded radiating costae.

"The large ligamental area indicates relationship with *B. grandis* and *B. obesa,* both of which are restricted to a higher horizon. The first is sufficiently distinguished by its carinate umbones; the second is a more erect shell, with a shorter hinge line, narrower area, and differently shaped byssal depression. The wide area should separate the species at once from *B. radiata* with which a careless collector might confound it.

"*Formation and locality:* Middle beds of the Cincinnati group, Cincinnati, Ohio."—Ulrich, *loc. cit.*

1.34A15a, 19-21, C13, 14a, 14b.

BYSSONYCHIA GRANDIS Ulrich.

Plate XLIV, figs. 1, 1a.

Byssonychia grandis Ulrich, 1893, Geol. Ohio, VII, p. 631, pl. xlvi, figs. 6-9.

"Shell large, ventricose, subquadrate, the length and hight as ten is to thirteen; anterior margin sinuate above, broadly convex in the lower two-thirds; outline of basal half semicircular; hinge line about two-thirds as long as the shell is at the middle of the hight. Beaks projecting less than usual, carinate, flattened on the anterior side; apices separated widely, the intervening space occupied by a broad, striated ligamental area. Upper part of the anterior side with a broad and deep impression in the bottom of which lies the byssal opening. Surface marked with about forty radiating costae. These are rounded and broad in the lower half of the shell. Posterior lateral teeth small, two, situated near the extremity of the hinge.

"This species probably attained a larger size than any other known. It may be equaled in this respect by the associated *B. cultrata,* a species that resembles it in its outline and in having carinate umbones as well. But the present species is readily distinguished from that one by its greater convexity, coarser and therefore fewer costae, and by the large depression around the byssal opening, this part of the shell being quite flat in that species. The ligamental area, furthermore, is of a peculiar type and much narrower in *B. cultrata,* allowing the beaks to come into close proximity. Despite the somewhat striking agreements, I am well satisfied that the two species are widely distinct. In *B. robusta,* Miller, sp., the whole anterior side is flattened, the outline different, and the beaks do not curve forward as in this species, nor are they as widely separated. Despite these and other differencies, I wish it to be understood that I think it just possible that *B. grandis* is not distinct from the species *intended* by Mr. Miller. I tried to see his types but failed because they were packed away. I am therefore obliged to rely upon his illustrations and to assume that they are correct. Comparing my specimens with his figures it will be noticed that in the convexity of the valves and the number of costae the two species agree very well, but in all other respects they are so obviously different that we are forced to regard them as specifically distinct. The carinate umbones will distinguish the species from all the other forms of the genus.

"There remains to mention that the outline of the shell and the coarse rays, which however are rounded instead of flattened, remind one of *Anomalodonta gigantea,* Miller. That species, however, is not so ventricose, and is without the large depressed area which surrounds the byssal opening of *B. grandis.*

"*Formation and locality:* Upper beds of the Cincinnati group. Oxford and Clarkesville, Ohio."—Ulrich, *loc. cit.*

1.34A1, 8, B4-5....1.41E1.

BYSSONYCHIA OBESA Ulrich.

Plate XLII, figs. 8-8b.

Byssonychia obesa Ulrich, 1893, Geol. Ohio, VII, p. 630, pl. xlv, figs. 10-12.

"Shell usually of less than medium size, obese, ovate in outline except where the full and prominent beaks project beyond the regular curve; hinge short, rounded behind; byssal opening small, situated high, the inner margin thickened so that a decided depression is formed in the anterior side of casts of the interior. Radii from forty-two to forty-five; length from 20 mm. to 33 mm.; height (from beak to base) from 26.5 mm. to 40 mm.; thickness from 15 mm. to 25 mm. In one specimen that differs a little from the rest these measurements are respectively 27 mm., 38 mm. and 20 mm.

"This species rarely occurs except in the condition of casts of the interior, but these are easily distinguished from *B. radiata* Hall, sp., with which collectors have generally identified them, by their more ventricose valves, more rounded form, and deeper byssal excavation. From *B. vera* the species is separated by its greater size, and more ventricose valves. *B. grandis* is much larger and has carinated beaks, they being flattened on the anterior side; *B. suberecta* is a more erect shell and has a longer hinge. Probably nearer than any of these species, at any rate in the general expression of casts of the interior, is the Galena limestone species described by Meek and Worthen as *intermedia* (*Ambonychia intermedia*). Young specimens may be difficult to distinguish from that species, but I have not yet seen any of *B. obesa* that were as small as the largest of *B. intermedia.* Aside from the point of size, comparison shows that the Galena species is, relatively speaking, higher, and that the outline is less rounded, especially in the postero-cardinal region.

"Two large specimens from a lower horizon (about fifty feet below the tops of the hills at Cincinnati), may belong to an early variety of this species. As, however, they had at least fifty radii we might be equally justified in regarding them as examples of a gigantic variety of *B. vera.* The length of the larger of the two is about 60 mm.

"*Formation and locality:* Near the top of the Cincinnati group at Richmond, Indiana, where it occurs in association with *B. richmondensis,* Ulrich, and *Ortonella hainesi,* Miller, sp."—Ulrich, *loc. cit.*

1.34A17 (?)....1.41A7, 8, D1, 3, E1, 2, 3, 5, 6. A common Whitewater species.

BYSSONYCHIA PRAECURSA Ulrich.

Plate XLIII, figs. 3, 3a.

Byssonychia praecursa Ulrich, 1893, Geol. Ohio, VII, p. 633, pl. xlv, figs. 1, 2.

"This form I regard as a small forerunner of *B. richmondensis, B. robusta,* and possibly of *B. cultrata* as well. The shape agrees best with *B. richmondensis,* the principal difference being in the hinge line which is always longer and sometimes quite equal to the greatest length of the shell. The number of the costae varies from thirty-eight to forty-two, the average number being the same as for *B. robusta* and ten less than in *B. richmondensis.*

"In the number of costae and in the outline *B. praecursa* is very much like the typical form of *B. radiata,* Hall, sp. As a rule, however, the latter is a little more oblique, the hinge shorter and the central part of its valves a trifle wider. But the principal difference lies in the flattening of the anterior side in *B. praecursa.*

"*Formation and locality:* Loraine shales, Loraine, New York; also in the equivalent middle beds of the Cincinnati group, at Covington, Kentucky, and Cincinnati, Ohio."—Ulrich, *loc. cit.*

1.12A2.

BYSSONYCHIA RADIATA (Hall).

Plate XLIII, fig. 4.

Ambonychia radiata Hall, 1847, Pal. New York, I, p. 292, pl. lxxx, figs. 4 a-l.

"Equivalve, obliquely ovate, extending into acute curving beaks; anterior slope nearly straight above, and rounded below; posterior slope oblique, scarcely alate; surface marked by twenty-five to forty strong simple radii, which are crossed by fine concentric striae; radii flattened upon the top; the intermediate spaces are regularly concave grooves, narrower than the radii, and marked by concentric striae.

"This species has usually been referred to *Pterinea carinata* of GOLDFUSS, but it appears to me specifically distinct. The figure of that author, which is larger than figs. 4 *a, b* of our plate, represents the shell as having twenty-three or twenty-four radii, which are proportionally stronger than in this shell, while specimens of equal size with the figure of GOLDFUSS have from thirty-five to forty radii upon each valve. On this account, principally, I am disposed to consider the succeeding species [*Ambonychia carinata*] as identical with that of GOLDFUSS.

"I regard both this and the following species as differing sufficiently from PTERINEA of GOLDFUSS to be separated from that genus, and to constitute species under the Genus AMBONYCHIA, which is destitute of an anterior wing, while the posterior side is expanded, though scarcely alate, never showing the distinct wing which marks the AVICULA and nearly all the species of PTERINEA.

"These specimens, though from different and widely distant localities, have all the same essential characters, and the radii are always smaller and more numerous than the one cited. It differs from *A. bellistriata* and *A. orbicularis* of the Trenton limestone, both of which have finer radii and are of different form.

"*Position and locality*: This is one of the most common fossils of the Hudson-river group, being found throughout the greater part of its thickness, but is unknown in the Trenton limestone or Utica slate. It is abundant at Boonville and Turin, in Lewis County [New York]; at Loraine, Jefferson County; at Pulaski, Washingtonville and Mexico, Oswego County; near Rome in Oneida County; and I have seen a single specimen from the altered slates near Waterford, Saratoga County. This species is likewise common in many western localities, and I have specimens from Cincinnati and Oxford (Ohio), Madison (Indiana), and Maysville (Kentucky)."—Hall, *loc. cit.*

1.34B4-5, C14b....1.41A8.

BYSSONYCHIA RICHMONDENSIS Ulrich.

Plate XLIV, figs. 2, 2a.

Byssonychia richmondensis Ulrich, 1893, Geol. Ohio, VII, p. 632, pl. xlv, figs. 3, 4.

"Shell large, high, triangular in a cardinal view, the anterior side being flat; height, length and thickness of an average specimen, respectively, 57 mm., 37 mm. and 30 mm. Beaks rather prominent, triangular, carinate, curving very slightly forward, and rather widely separated in casts. Anterior outline nearly straight, the margin projecting a little in the lower part; base strongly convex, posterior margin broadly rounded; hinge line about two-thirds as long as the middle length of the shell, ranging at an angle of about 95° with the anterior margin. Byssal opening large, in casts appearing as an acutely elliptical low prominence, situated about its length beneath the summits of the beaks. Costae of moderate strength; their number, though not certainly determined, is not less than fifty. Posterior adductor scar and pallial line as shown on plate 45 [of Ulrich's paper].

The shell of this species has not been observed, but the casts are not uncommon, and with their broadly flattened and nearly straight anterior sides are so easily distinguished from all other species of the genus, except *B. robusta,* Miller, sp., that a name for them has long been desirable. In 1880 (*loc. cit.*) Mr. Miller referred these casts to his species *robusta,* but in a recent conversation he admitted that they probably belonged to a distinct species. *B. robusta,* as figured, is relatively not so high and has coarser rays, their number being only about forty, while in *B. richmondensis* there are at least ten more. *B. cultrata* is closely related, but differs decidedly in its outline, being a wider shell and not so convex. The flattening of the anterior side also is confined to the upper part, while in the lower part the outline curves forward in a much greater degree.

"*Formation and locality:* Associated with *Rhynchonella dentata,* Hall, and *Ortonella hainesi,* Miller, sp., in the upper beds of the Cincinnati group at Richmond, Indiana."—Ulrich, *loc. cit.*

This species is considered by Ulrich as equivalent in part to *Byssonychia robusta* Miller, 1880, Jour. Cin. Soc. Nat. Hist., III, p. 315.

The types are from the Richmond formation at Richmond, Indiana, where the species is associated with *Rhynchotrema dentata*.

1.34A19-21, 22....1.41A6....1.60H11.

BYSSONYCHIA SUBERECTA Ulrich.

Plate XLIV, figs. 3-3b.

Byssonychia suberecta Ulrich, 1893, Geol. Ohio, VII, p. 634, pl. xlv, figs. 13-15.

"Shell exceeding the medium size for the genus, moderately convex, suberect, the length and height as five is to six. Hinge line forming an angle of about 105° with the anterior margin; this is a few degrees wider than the posterior angle. Anterior outline gently sinuate in the upper half, and in the central part bending forward enough to give the shell the appearance of leaning backward rather than forward; posterior margin broadly convex; basal half with a semicircular curve. Beaks full, rounded, not very prominent, bending somewhat forward and strongly incurved. Greatest convexity in the umbonal region, but taking the surface as a whole it is more uniformly rounded than in any other species of the genus. Radiating costae rather small, fifty-five to fifty-eight on each valve. Ligamental area about 3 mm. wide, almost vertical, so that in a dorsal view it appears as very narrow, with five or six distinct longitudinal striae. Cardinal teeth apparently three in each valve. Strong posterior lateral teeth are present, but whether more than one in each valve could not be learned from the material at hand. Byssal opening long though very narrow. Muscular and pallial impression as usual for the genus. In casts of the interior the beaks are comparatively erect and obtusely pointed.

"This species has an outline that is closely similar to that of *B. cultrata*. The two species are also associated in the same strata, but can be distinguished at once by the rounded instead of carinated beaks of *B. suberecta*. The latter is also a little smaller. *B. radiata* is probably more nearly allied, but has fewer costae and is a much more oblique shell.

"*Formation and locality:* Upper beds of the Cincinnati group, at Waynesville, Ohio, and Versailles, Indiana."—Ulrich, *loc. cit.*

1.34A4 (?), 20....1.41A5, 7, E1, 6....1.12F3.

BYSSONYCHIA TENUISTRIATA Ulrich.

Plate XLIII, figs. 5, 5a.

Byssonychia tenuistriata Ulrich, 1894, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 500, fig. 39.

"Shell rather small, subovate, moderately ventricose in the umbonal region and anterior half, compressed in the postro-cardinal region where the surface is distinctly concave; anterior slope strongly convex, but scarcely abrupt; beaks small, projecting but little, moderately incurved. Hinge line comparatively short, the outline passing rather gently into the broadly-rounded posterior margin; basal line strongly convex, curving uniformly into the ends; anterior side slightly concave above, neatly convex below. Byssal opening small, its position high, it and the surface around it appearing in casts as a distinct impression immediately beneath the beaks. Surface marked by very fine radiating striae and obscure concentric varices of growth, both showing through the marginal parts of the shell, so as to be visible on good casts of the interior. The total number of the radiating striae is probably more than seventy. Near the base of the specimen figured eleven were counted in the space of 5 mm.

"This species is closely related to *B. vera* Ulrich, from the Utica horizon of the Cincinnati group of Ohio, differing from it chiefly in its finer radiating striae and more impressed byssal opening. *B. intermedia* M. and W., of the Galena, has coarser striae and is a more ventricose shell.—Ulrich, *loc. cit.*

Reported by Ulrich from the Richmond formation at Richmond, Indiana.

CLIDOPHORUS FABULA (Hall).

Plate XLIV, figs. 6, 6a.

Nucula fabula Hall, 1845, Amer. Jour. Sci., XLVIII, p. 295. (Not figured.)

"Shell twice as wide as long, smooth; beaks moderately prominent; crenulations along the hinge-line very obvious; muscular impressions on the anterior side of the beaks very distinct in the cast.

"Width of largest specimen 1/12 of an inch; generally less."—Hall, *loc. cit.*

Our view of this species rests rather upon the description of Meek than upon the inadequate description of Hall, given above. I therefore quote Meek's description in full:

"Shell minute, or very small, transversely-subelliptic, moderately convex; extremities narrowly rounded, the anterior end being narrower than the posterior; basal margin forming a broad semi-elliptic curve; beaks rather depressed, slightly tumid, and placed a little in advance of the middle; dorsal margin sloping gently from the beaks, the anterior slope being rather less gradual than the other, and, in the cast, a little concave in front of the beaks. Anterior muscular impressions distinctly defined by the internal ridge, which leaves a rather deep furrow just in advance of each beak in casts of the interior.

"Lenth, 0.06 inch; height, 0.03 inch; convexity, about 0.02 inch."

1.34B4-5.

CLIONYCHIA EXCAVATA Ulrich.

Plate XLIV, figs. 4, 4a.

Clionychia excavata Ulrich, 1893, Geol. Ohio, VII, p. 651, pl. li, figs. 4, 5.

"Shell as seen in a cast of the interior, of medium size, erect, strongly convex, subquadrangular, straight above, slightly sinuate anteriorly, and rounded below and posteriorly; post-cardinal angle obtuse, perhaps rounded; length of hinge line about two-thirds of the greatest width (length) of the shell; length and height respectively as six is to seven. Beaks compressed, scarcely projecting above the hinge, separated by an unusually wide interval; between and beneath them the greater part of the upper half of the anterior side of the shell is deeply excavated. Muscular scar situated lower than usual, placed just behind the center of the valves. Surface of cast with distant lines of growth in the outer half.

"The hinge is shorter and the anterior excavation larger than in *C. lamellosa* and *C. erecta,* two species of the lower Trenton rocks of Minnesota and Wisconsin."—Ulrich, *loc. cit.*

The types are from the Richmond formation at Richmond, Indiana.

CTENODONTA CINGULATA Ulrich.

Plate XLIV, figs. 5, 5a.

Tellinomya cingulata Ulrich, 1879, Jour. Cin. Soc. Nat. Hist. II, p. 23, pl. vii, figs. 19, 19a.

"Shell of medium size, nearly circular, with a slight prolongation of the posterior end, thus giving a little obliquity to the shell; anterior and basal borders regularly rounded; posterior cardinal margin slightly rounded and sloping to the point of greatest extension; beaks small, obtusely pointed, and not incurved; valves moderately convex, somewhat depressed just posterior to the beaks, and along the cardinal margin.

"Hinge plate wide, regularly, and rather strongly arched, occupied by eight to ten teeth on each side of the middle, those at the extremities bent to about a right angle, becoming more and more straight toward the center.

"Surface ornamented by from six to eight very fine concentric lines.

"Muscular impressions and pallial lines not observed.

"Length, 0.72 inch; height, 0.68 inch: convexity, 0.22 inch.

"This species is related to *T. pectunculoides,* Hall, but its more circular form, less prolonged posterior border; the fine concentric striae and its larger size, will serve to distinguish them externally, while its smaller number of teeth, wider hinge-plate, and more abrupt curvature of the same, will separate them internally."—Ulrich, *loc. cit.*

The types are from the top of the Richmond formation at Marble Hill, near Madison, Indiana.

1.12E3.

CYMATONOTA TYPICALIS Ulrich.

Plate XLV, figs. 1-1c.

Cymatonota typicalis Ulrich, 1893, Geol. Ohio, VII, p. 662, pl. lv, figs. 1-5.

"Shell elongate with the dorsal and ventral margins parallel, the length three and one-half times the height, the greatest thickness, which is a little behind the center, about two-thirds of the height; anterior end nearly vertical, rounded but not uniformly, the turn into the hinge line being rather abrupt; posterior margin rounded, slightly oblique, most prominent in the lower half; ventral margin gently concave. Beaks appressed, scarcely prominent, situated one-fifth of the length of the shell behind the anterior extremity; umbonal ridge and mesial sulcus rather distinct features, cardinal region anterior to the beaks sharply compressed. Surface with fine equal striae anterior to the beaks, of which not over half continue over the flanks of the shell where they take on an irregular character, some being much stronger than the others; or several may be united into a fold. The umbonal ridge is almost smooth, but the upper part of the posterior cardinal slope is marked with rather regular, strong, oblique folds."—Ulrich, *loc. cit.*

The types are from the Richmond formation at Waynesville, Ohio.

1.34A8....1.41E6.

CYRTODONTA CUNEATA (Miller).

Plate XLV, fig. 2.

Angellum cuneatum Miller, 1878, Jour. Cin. Soc. Nat. Hist., I, p. 106, pl. iii, fig. 11.

"Shell medium size, equivalve, much elongated from the cardinal line to the base, middle part subcylindrical, where width and depth are sub-equal; lower half wedge-shaped; umbones high, angular, and prominent anteriorly; beaks acuminate and incurved over the cardinal line; hinge line straight, short, and nearly at right angles to the longer axis of the valves. The cast is a little convex on the anterior side, where there is some evidence of a byssus, and slightly winged on the posterior margin. Surface marked by concentric lines.

"The specimen illustrated I collected in the upper part of the Cincinnati Group, at Richmond, Indiana."—Miller, *loc. cit.*

ISCHYRODONTA DECIPIENS Ulrich.

Plate XLV, figs. 3-3c.

Ischyrodonta decipiens Ulrich, 1893, Geol. Ohio, VII, p. 673, pl. liv, figs. 16-19.

"Shell scarcely attaining medium size, moderately convex, the beaks small, the umbonal ridge distinguishable though not strong, the outline almost regularly oval excepting that the cardinal region is produced and angular at the posterior extremity. Surface marked with numerous, strong and more or less irregular concentric lines of growth. Cardinal teeth nearly horizontal, three in the right valve, the central tooth much the largest, and two in the left valve. Posterior to the cardinal teeth the hinge plate bears three or four slightly diverging slender ridges, which served as supports for the internal ligament. Muscular impressions subequal, strongly marked, the anterior one especially; pallial line distinct. Internal umbonal ridge undefined so that the surface of casts of the interior is comparatively even.

"This species is founded upon an excellent series of specimens, most of them recently obtained from Prof. Joseph Moore and Mr. John Misener of Richmond, Indiana. One specimen I had for at least ten years believed to belong to the similar *Ortonella hainesi* Miller, sp., and it is the likelihood of confusion with that species that has suggested the name *decipiens*. A careful comparison, however, brings out a number of differences that will appear very obvious to the student after he has once made himself familiar with them. First, the surface markings are much coarser in the *Ischy-*

rodonta; next, the outline will be found to be not strictly the same; then the *Ortonella* has a well developed lunule and escutcheon, while the margin of the valves of the *Ischyrodonta* are not in the least inflected; finally that shell has a different hinge, having true posterior lateral teeth.

"Compared with species of this genus, *I. ovalis* will be found to have a thinner hinge plate and more regularly oval shape, while *I. truncata* is a higher shell, with fewer concentric surface markings, and much more oblique cardinal teeth."—Ulrich, *loc. cit.*

Reported by Ulrich from near the top of the Cincinnati group at Richmond, Indiana.

ISCHYRODONTA ELONGATA Ulrich.

Plate XLV, figs. 4, 4a.

Ischyrodonta elongata Ulrich, 1890, Am. Geol., VI, p. 175, figs. 12 a-c.

"Of this species only casts of the interior have been seen. These may be described briefly as follows: Shell rather large transversely elongate-ovate, widest posteriorly, strongly convex, with point of greatest convexity a little in front of the middle. Beaks prominent, compressed, almost terminal. Cardinal margin convex; posterior margin rather strongly convex, and generally somewhat straightened in the lower half; basal margin straight or faintly sinuate; anterior end abruptly rounded, very short. Anterior muscular scar deep, subquadrate, situated beneath the beaks. Just above it the small accessory scar.

"The much greater length of this shell distinguishes it from *I. truncata,* with which it is associated. The outline is much like *Modiolopsis modiolaris* Conr., but the casts of that species are not so convex and the beaks less prominent.

"Associated with this species and *I. truncata* I found several examples of a form apparently intermediate in character between the two. They are, unfortunately, not in very good condition, but as far as they admit of comparison it would appear that they represent nothing more than a slightly elongate variety of *I. truncata.*" —Ulrich, *loc. cit.*

Reported from near the top of the Cincinnati Group at Oxford, Ohio, and Richmond, Indiana.

1.34A18b.

ISCHYRODONTA MISENERI Ulrich.

Plate XLV, figs. 5-5a.

Ischyrodonta miseneri Ulrich, 1893, Geol. Ohio, VII, p. 675, pl. liv, figs. 10, 11.

"This species, as far as known, is very similar to *I. elongata*, and a detailed description is scarcely necessary. Though agreeing in most respects very closely with that species, a comparison still brings out differences that doubtless will suffice in discriminating between the two species. The shell of *I. miseneri* is considerably smaller (the largest seen is about 38 mm. in length), comparatively a little shorter, and subtriangular in outline. The posterior margin is more oblique and considerably higher, and its junction with the straight cardinal margin angular, while the post-cardinal region is distinctly alate and thus quite different from the rounded and sloping character of this part of the outline in *I. elongata*. The umbonal ridge furthermore is a more decided feature. Of the other species *I. decipiens* is much shorter, *I. modioliformis* longer, and more produced and obliquely rounded posteriorly.

The specific name is given in honor of Mr. John Misener of Richmond, Indiana, who collected and from whom I received the best specimens of the shell seen."—Ulrich, *loc. cit.*

According to Ulrich this species occurs at Richmond, Indiana, in association with *Rhynchotrema dentata,* that is in the Whitewater division.

ISCHYRODONTA MODIOLIFORMIS Ulrich.

Plate XLV, figs. 6-6c.

Ischyrodonta modioliformis Ulrich, 1893, Geol. Ohio, VII, p. 676, pl. liv, figs. 4-9.

"Shell scarcely attaining medium size, moderately convex, modiola-like, elongate subovate, the base straight or very gently sinuate, the back straight for a short distance behind the beaks, then curving very gradually down into the very obliquely rounded posterior margin; anterior end short, sharply rounded, much narrower than the posterior. Beaks small, situated a short distance behind the anterior extremity; both the mesial sulcus and the umbonal ridge are but little developed. The cardinal slope and the posterior part of the surface is marked with rather strong, subregular, concentric furrows, of which from ten to fourteen may be counted in the space of 10 mm. Besides these furrows a set of very fine concentric lines, barely visible to the unaided eye, are to be observed on well preserved specimens. The anterior part of the surface seems to be smooth, the furrows at any rate ceasing suddenly a short distance in front of the middle of the shell.

"In casts of the interior a narrow and more or less distinct umbonal ridge may be traced from the beak to the pallial line a short distance behind the center of the cast, while in front of the ridge there is usually a well defined depression or sulcus. Anterior muscular scar strongly elevated, very oblique, sharply defined on the upper side, occupying the greater part of the small anterior end and extending a little posterior to the points of the beaks. Posterior scar very faintly impressed, nearly twice the size of the anterior, situated just within the sloping post-cardinal border of the cast. Pallial line distinct only in the ventral part of the valves. Close to the cardinal border of the casts a long and slightly impressed line represents the support of the internal ligament. Of cardinal teeth there seem to have been but two, one in each valve, the right above the left. The scars left by the small pedal muscles occupy the usual position immediately in front of the cavity between the filling of the beaks.

"This well marked species, of which I have seventeen specimens, is probably nearest *I. elongata*. It is, however, a much smaller shell and readily distinguished by its narrower form, more oblique posterior margin, and different surface markings, the concentric lines of growth extending almost uniformly over the whole surface in that species.

"In a general way *I. modioliformis* greatly resembles several species of *Modiolopsis*, but that it is not really related to them is proved by the fact that it has the shell structure, cardinal teeth and small anterior pedal muscles of a true *Ischyrodonta*."—Ulrich, *loc. cit.*

The types are from the Richmond formation at Richmond, Indiana.

1.41E1, 4.

ISCHYRODONTA OVALIS Ulrich.

Plate XLV, figs. 7-7b.

Ischyrodonta ovalis Ulrich, 1892, Geol. Nat. Hist. Surv. Minnesota, Ann. Rep. XIX, p. 242, fig. 27 a-d.

"Shell small, moderately ventricose, almost regularly elliptical in outline, with the greatest width and thickness midway between the ends; width and length about as two is to three. Beaks small, situated near the anterior extremity, compressed by a flattening of the surface which, expanding, extends over the greater part of the ventral slope. Edges of valves meeting at the center of the ventral margin, apparently gaping a little at the ends. Umbonal ridge prominently rounded, cardinal slope abrupt, very little concave. Surface marked with strong lines of growth and a few finer concentric striae, both inclining to be irregular.

"Hinge plate arcuate, widening posterior to the beaks, grooved as for the reception of an internal ligament. Cardinal teeth two, projecting downward and backward from the hinge plate, which is thin at this point, and supported by an internal process that seems to extend up into the cavity of the beak, and projects on each side of the teeth so as to give the whole the appearance of a quadrifid tooth. Anterior muscular scar rather small, occupying the anterior extremity of the shell.

"This species is not strictly congeneric with the types of *Ischyrodonta* (Amer. Geol., vol. 6, pp. 173-175), but there is no other established genus known to me offering a closer agreement, and before I can consider the erection of a new genus as fully justified, I wish to see the main peculiarities of the shell confirmed in other species. The uncertainty of the position of the species is increased by the fact that it might be referred, with equal propriety perhaps, to the genus *Matheria,* of Billings. I infer therefore that we are dealing with an undescribed generic type having somewhat intermediate relations between *Matheria* and *Ischyrodonta.*"—Ulrich, *loc. cit.*

Reported by Ulrich from the uppermost beds of the Cincinnati group, near Richmond, Indiana.

ISCHYRODONTA TRUNCATA Ulrich.

Plate XLV, figs. 8-8c.

Ischyrodonta truncata Ulrich, 1890, Am Geol., VI, p. 174, figs. 11 a-e.

"Shell of medium size, moderately convex, subquadrate to broad-oval, widest posteriorly. Cardinal margin straight or faintly arcuate, nearly as long as the shell. Anterior end very short, rounding uniformly into the convex basal margin. From here the edge makes a sharp turn (in the post-basal region) into the somewhat truncate but convex posterior margin, meeting the posterior extremity. Surface of the thick shell smooth between a limited number of impressed lines of growth.

"Hinge plate thick and wide, flat; the cardinal teeth strong.

Anterior muscular impression deep, its outline somewhat top-shaped, pointed below where the well marked pallial line runs into it. Posterior scar very faint, large subcircular, situated near the postero-cardinal angle. In casts of the interior the beaks are prominent, compressed, while a well marked furrow extending from the beaks nearly to the center of the base, gives rise to an obtuse umbonal ridge of which no sign is apparent on the exterior of the shell. Another but less deep and shorter furrow occurs in the space between this and the anterior muscular scar.

"An average specimen of the typical form has the following dimensions: Greatest length, 35 mm.; greatest hight, (from posterior extremity of hinge line to posterior portion of base) 30 mm.; from postero-cardinal angle to antero-basal region 31.5 mm.; from beaks to postero-basal region 35 mm.; greatest convexity of a cast of the interior of a specimen of the same size, 16 mm.

"This species ought not to be confounded with any other known to me from the Cincinnati rocks. I have seen specimens of it labelled *Cypricardites hainesi* S. A. Miller, a shell occupying the same horizon, but there is little reason for confusing the two since Miller's species has posterior cardinal teeth, is less convex, and not so high posteriorly."—Ulrich, *loc. cit.*

This species is reported by Ulrich from Richmond, Indiana. near the top of the Cincinnati group (Whitewater division).

ISCHYRODONTA UNIONOIDES (Meek).

Plate XLVI, figs. 1, 1a.

Anodontopsis ? unionoides Meek, 1871, Amer. Jour. Sci., 3d. ser., II, p. 299. (Not figured.)

"This species has at least all the external characters of the genus, including the last, but nothing is known of the nature of its hinge. Specifically it differs from the species *Milleri*, not only in being very much larger than the adult size of that shell, but in having its anterior outline more regularly rounded, and its posterior obliquely subtruncated above, and with its most prominent part below the middle. Its ventral margin is also much straighter in outline; while its beaks are more depressed and placed decidedly nearer the anterior side, and its dorsal margin is not declining on the posterior side of the beaks as in the last. It likewise differs in having its posterior umbonal slopes more convex on a line from the beaks to the posterior basal margin.

"Length, 1.73 inches; height, 1.11 inches; convexity, 0.63 inch."—Meek, *loc. cit.*

Reported by Meek from the same locality as *A. milleri.* (=*Orthodontiscus milleri.*)

MODIOLODON DECLIVIS Ulrich.

Plate XLVI, figs. 2, 2a.

Modiolodon declivis Ulrich, 1893, Geol. Ohio, VII, p. 654, pl. liii, figs. 3, 4.

"Of this species also only casts of the interior have been seen. These are so much like those of *M. subrectus* that a detailed description is unnecessary. On comparing the casts we find that *M. declivis* is more elongate, the length being twice as great as the height; the ventral margin is slightly sinuate instead of straight, and the dorsal margin arcuate, the posterior part sloping downward in a manner quite unusual in this family of shells. The two ends are nearly equal, the posterior one being therefore relatively narrower than in *M. subrectus.*"—Ulrich, *loc. cit.*

The types are from the Richmond formation, at Richmond, Indiana.

1.34B4-5 (?)

MODIOLODON OBTUSUS Ulrich.

Plate XLVI, figs. 4, 4a.

Modiolodon obtusus Ulrich, 1893, Geol. Ohio, VII, p. 654, pl. lii, figs. 20, 21.—*Modiolopsis modiolaris,* Hall and Whitfield, 1875, Pal. Ohio, Vol. II, plate II, fig. 17. (Not *M. modiolaris,* Hall, 1847, nor *Pterinea modiolaris,* Conrad, 1838.)

"Shell large, compressed-convex, oblong, subovate or obscurely quadrangular, highest behind, though unusually wide and blunt in front. Cardinal margin very long, distinctly arcuate, passing gradually into the regularly curving anterior margin; post-cardinal angle obtuse, sometimes rounded but always projecting beyond the line of a regular curve; posterior margin nearly erect, not strongly curved, except at the base where the outline turns rapidly forward into the basal line, which may be straight or more or less sinuate. Ventral and dorsal margins nearly parallel in the posterior two-thirds, the height in this part of the shell comparing with the length about as six to eleven, while the height at the beak is represented by a little more or less than four. Beaks small, scarcely distinguishable, situated very near the anterior end; umbonal ridge inconspicuous, low, defined only on the lower side by the broad mesial depression. Surface marked by rather fine concentric lines of growth. Shell thick, especially in the anterior part. Anterior muscular scar large, deep, of rounded or ovate shape. Hinge plate wide, furnished with long cardinal teeth immediately over the muscular scar. There appear to be three teeth in all, one large one in the right valve and two more slender in the left.

"In a form obtained from the upper beds of the Cincinnati group, which I shall consider provisionally as belonging to this species, the anterior end is narrower and the anterior muscular scar almost straight on the inner side. A good specimen measures as follows: length, 79 mm.; central height, 43 mm.; anterior height, 23 mm. It is this variety that seems to correspond with the figure given, as above cited, by Hall and Whitfield as of *Modiolopsis modiolaris*. If this specimen is correctly represented by their drawing, it cannot belong to Conrad's species nor even to the genus *Modiolopsis*, since it had well developed cardinal teeth.

"This large shell finds its nearest congeners in the three species described on the preceding pages and figured on plate 53 [of Ulrich's paper], but as the means for comparison are thus at hand and as the differences between the forms must be obvious to every one, it is not necessary to point them out."—Ulrich. *loc. cit.*

Hall and Whitfield report this species from Cincinnati, Ohio. The typical form of the species occurs at Cincinnati about 350 feet above low water of the Ohio River.

1.34A8.

MODIOLODON SUBOVALIS Ulrich.

Plate XLVI, figs. 3-3b.

Modiolodon subovalis Ulrich, 1893, Geol. Ohio, VII, p. 655, pl. li, figs. 11-13.

"Shell, as seen in casts of the interior, subovate, highest posteriorly, rather compressed-convex, thickest a little above the middle, the hight and length about as two is to three; length varying in different specimens between 35 mm. and 50 mm. Dorsal outline slightly arcuate; posterior margin somewhat oblique, generally a little straightened (scarcely truncate) in the upper half and well rounded in the lower, at other times more uniformly curved; base broadly rounded, ascending anteriorly; anterior end very short and small, regularly curved. Beaks very small, scarcely distinguishable, situated far in front; no distinct umbonal ridge; mesial sulcus comparatively deep in the umbonal half, not sharply defined however anywhere.

"Anterior muscular scar very faint, prominent, occupying about half of the small anterior end; pallial line moderately distinct, submarginal posterior scar very faint, back of cast deeply channeled, indicating either a strong hinge plate or an escutcheon in the shell, the former most likely. Cardinal teeth were present but they are not shown clearly enough in casts to be described. Surface of casts with a few distant lines of growth.

"This species is closely related to *Modiolopsis truncata,* Hall, but may be distinguished by its more nearly oval outline, and deeper mesial or umbonal sulcus. In the outline it is more like the type of the genus *M. oviformis* but the casts of that species are not channeled dorsally in any degree comparable with *M. subovalis.*

"Respecting the generic position of the species, I see nothing to oppose an arrangement with *Modiolodon.* The same applies also to *Modiolopsis truncata,* because it is unquestionably congeneric with *M. subovalis.* Until the latter was discovered and studied I found Hall's species (*truncata*) most troublesome to classify, and for a time I was inclined to place it into the new genus *Eurymya,* founded upon *Modiolopsis plana,* Hall."—Ulrich, *loc. cit.*

From the Richmond formation at Versailles, Indiana, and reported in Kindle's list from Richmond, Indiana.

MODIOLODON SUBRECTUS Ulrich.

Plate XLVI, figs. 5-5a.

Modiolodon subrectus Ulrich, 1893, Geol. Ohio, VII, p. 653, pl. liii, figs. 5, 6.

"This species is known only from casts of the interior. Of six specimens the largest is 47 mm. long and 27 mm. high, the smallest 29 mm. long and 17 mm. high. Cardinal and basal margins nearly straight and subparallel, diverging slightly posteriorly; posterior margin obliquely subtruncate, obtuse-angular above, more prominent and strongly rounded in the lower half; anterior end short, small, the upper margin sunken considerably beneath the dorsal outline. Beaks compressed, prominent anteriorly, situated well forward, on a line with the back, scarcely incurved, separated by a well defined, wide, channel-like depression extending posteriorly from the points of the beaks half the length of the cast. Umbonal ridge and sulcus strong, extending from the beaks obliquely downward to the central third of the base; and producing a decided compression of the antero-basal third of the cast. Anterior muscular scar very strong, obliquely ovate, large, occupying the greater part of the small anterior end. The inner side of the elevated scar is marked with about six horizontal folds. Pallial line and posterior adductor impression indistinct. The casts exhibit no indications of the surface markings. The hinge plate seems to have been strong, while of cardinal teeth the evidence at hand indicates two in each valve, one larger than the other.

"The casts of this species might be confounded with those of small specimens of *Ischyrodonta elongata,* Ulrich, but a careful comparison will show that the *Modiolodon* is narrower posteriorly, the dorsal and ventral margins being more nearly parallel and also straighter; the ventral margin is not sinuate, and there is no small pedal muscular scar above the anterior adductor impression, while the inner side of the latter is thrown into folds instead of being sharply edged. Excepting the following species there is no other known to me with which it need be compared.

"That *M. subrectus* is not an *Ischyrodonta* is shown by the black film so characteristic of the *Modiolopsidae* which is retained by two of the specimens. The absence of the small pedal muscles over the anterior adductor impressions also is significant."—Ulrich, *loc. cit.*

The type is from the Richmond formation, Richmond, Indiana.

MODIOLODON TRUNCATUS (Hall).

Plate XLVI, figs. 6, 6a.

Modiolopsis truncatus Hall, 1847, Pal. New York, I, p. 296, pl. lxxxi, figs. 3 a-b.

"Oblique, transverse, sub-trapezoidal; the cardinal and basal margins diverging from the anterior extremity, convex; beaks near the anterior extremity, with an obscure elevated ridge extending obliquely to the base; posterior extremity obliquely truncate; muscular impression very distinct, a little in advance of the beaks, and at the anterior extremity, in the cast projecting beyond the margin.

"This shell differs but little from some of the varieties of *M. modiolaris;* but it is proportionally broader, and the beaks are closer to the anterior extremity, while the muscular impression seems to be placed upon the very margin of the shell. It is much less common than *M. modiolaris,* and the few specimens examined appear to be constant in the characters given. It bears a close resemblance to the figure of DE VERNEUIL cited above.

but it is less ventricose, our specimen being crushed and destitute of the shell."—Hall, *loc. cit.*

Reported by Hall from Cincinnati, Ohio. Reported from Indiana in Kindle's list.

MODIOLOPSIS CONCENTRICA Hall and Whitfield.

Plate XLVII, fig. 3.

Modiolopsis concentrica Hall and Whitfield, 1875, Pal. Ohio, II, p. 86, pl. ii, fig. 18.

"Shell of medium size; elongate ovate in outline; broadest near the posterior end, and contracted in front of the beaks. Hinge line arcuate, gradually declining toward the extremity and rounding into the posterior margin, which is more sharply rounded below than above the middle; basal line gently curved, becoming a little sinuate at or about the anterior third of its length; anterior end narrowly rounded. Beaks small, and compressed on the back, projecting but little above the hinge. Surface of the valves moderately convex when not distorted by pressure; most prominent above the umbonal ridge, which is low, and broadly rounded; not forming a conspicuous feature of the valve. A very slight and rather undefined mesial sulcus crosses the valves from the beak to the sinus of the basal margin.

"Surface of the shell marked on the cardinal slope and posterior end by regular, even, concentric furrows, from three to four of which occupy the space of an eighth of an inch in their strongest parts. These furrows are most distinctly marked near the cardinal margin, and become obsolete in crossing the umbonal ridge; existing on the basal portions and anterior end only as fine, irregular, concentric striae of growth. Anterior muscular impression strongly defined and proportionally large; forming a rather distinct, subcircular or reniform protuberance on the anterior end of the casts; posterior impression not observed; pallial line often distinct on the anterior half; partly composed of detached transverse pustules.

"The specimens of this shell observed in collections have generally been found among and considered as identical with those of *Modiolopsis modiolaris,* but it is always of much smaller size, being generally not more than two-thirds as long when fully grown as the ordinary sized individuals of that species, and although the general form is very similar, the concentric markings of the cardinal slope and posterior end readily distinguish them. These markings are of such a nature that they are usually preserved on all specimens retaining any specific markings. The specimens are frequently much distorted by compression, and when the pressure has been vertical, or in the direction of the plane of the shell, the convexity is considerably increased, often causing them to appear nearly cylindrical.

"The species resembles very closely *Modiomorpha concentrica* of the Hamilton formations of New York (*Modiola concentrica* of authors) in its general appearance and surface markings, so much so that it might readily be mistaken for that shell; but the concentric, undulating striae becoming obsolete on the umbonal and anterior portions of the shell, will serve, we think, as an unfailing means of distinguishing them—the striae on that species continuing over all parts."—Hall and Whitfield, *loc. cit.*

The types are from Waynesville, Ohio. Reported from Indiana in Kindle's list.

MODIOLOPSIS VERSAILLESENSIS Miller.

Plate XLVI, figs. 7, 7a.

Modiolopsis versaillesensis Miller, 1874, Cincinnati Quarterly Journal of Science, I, p. 150, figs. 18, 19.

"Equivalve, inequilateral, oblong, expanded and compressed posteriorly; basal margin contracted or arched upward, below the beaks; cardinal line straight; beaks near the anterior extremity, and slightly more prominent than those of the *Modiolopsis modiolaris;* umbones subangular and extending obliquely, posteriorly; surface marked by concentric lines; muscular impression circular and deep, below and anterior to the beak; mesial ridge between it and the umbonal cavity; hinge line plain and smooth, except a slight ligamental depression below the beak.

"Length of specimens examined varying from ¾ inch to 2½ inches; breadth and thickness in proportion to the length.

"This species differs from the *Modiolopsis modiolaris,* in having a more prominent beak, more angular umbones, different hinge line, and ligamentary attachments, and in having the muscular impression farther anterior to the beak. Casts of the two species might not be distinguishable from each other.

"This species was found by me at Versailles, Indiana, about 300 feet below the rocks of the Upper Silurian, and associated with *Anomalodonta gigantea, Anodontopsis* (?) *Milleri, Pleurotomaria tropidophora, Tellinomya occidentalis,* etc."—Miller, *loc. cit.*

Apparently Miller obtained the species from the Waynesville formation, or the base of the Liberty. His statement that the specimens came from a level 300 feet below the Upper Silurian is interesting in view of the fact that the total thickness of the Versailles section does not exceed 170 feet.

OPISTHOPTERA CASEI Meek and Worthen.

Plate XLVII, figs. 1, 1a.

Ambonychia (*Megaptera*) *casei* Meek and Worthen, 1866, Proc. Chicago Acad. Sci., vol. I, p. 23. (Also Geol. Surv. Ill., vol. III, 1868, p. 337.)

"Shell trigonal, compressed, subequivalve, extremely inequilateral, posterior side long, compressed and strongly alate; the wing very large, produced, pointed, and not separated from the alate posterior margin by a distinctly defined sinus; margin below the wing, sloping obliquely forward to the basal angle; cardinal margin the longest part of the shell, straight and much compressed from immediately behind the beaks. Anterior side truncated nearly vertically from the beaks, about half way down the front, thence sloping slightly backwards to the basal angle. Basal margin produced downwards, and terminating in a distinct angle, slightly in advance of the middle. Umbonal slopes very prominent, angular, or sometimes apparently bicarinate, straight, and extending from the beaks, near the anterior margin, to the most prominent part of the base, ranging at an angle of about 65° below the horizon of the hinge-line, and provided with a longitudinal sulcus below the middle of the valves. Beaks straight, rising a little above the cardinal margin, and quite terminal. Surface ornamented with distinct, irregular, alternately larger and smaller, thread-like radiating striae, with less distinct concentric lines, and a few distinct, stronger marks of growth, which sometimes form prominent, imbricating, subspinous projections on the umbonal angle.

"Length, as inferred from the direction of the lines of growth, about 2 inches; height, 1.73 inches; convexity, 0.64 inch."—Meek and Worthen, Geol. Surv. Ill., vol. III, 1868, p. 337.

I have not been able to obtain the Proc. Chicago Acad. Sci., 1866.

The description is followed by a discussion of the generic relations of the species, which I omit.

The type is from Richmond, Indiana.

1.12E3. F3....1.60H11.

OPISTHOPTERA OBLIQUA Ulrich.

Plate XLVII, figs. 2-2b.

Opisthoptera obliqua Ulrich, 1893, Geol. Ohio, VII, p. 646, pl. xlix, figs. 6-8.

"Shell small, trianuglar, highest in the posterior third, and thickest along the oblique anterior side; hinge line as long as the shell, posterior margin vertical, gently convex, basal margin narrowly rounded; anterior side very abrupt, almost flat, forming an angle of about 55° with the hinge. Beaks rather large, prominent, but little incurred [*sic.*] and separated by a considerable interval in casts of the interior. Ligamental area very wide. Surface marked with small, apparently bifurcating costae, of which those near the cardinal margin are if anything smaller than elsewhere. On the whole they may be described as subequal.

"This species doubtless is closely related to *O. extenuata*, the two species being very similar in their anterior halves. Still, it is highly improbable that they will ever be confounded, since they are so different posteriorly, this part of the outline being vertical and slightly convex in the present form and deeply sinuate centrally and prolonged above in that one. The ligamental area also is much larger in *O. obliqua*. Compared with *O. alternata* it is found that the valves though more convex are not as uniformly rounded, the anterior side more oblique and much more abrupt, and the costae of nearly equal size instead of alternately large and small. None of the other species are near enough to require comparisons.

"Associated with *O. obliqua* we find *Byssonychia richmondensis*, another species having the anterior side flat. But as it attains a much larger size, is relatively much higher and almost erect, and has a much shorter hinge, they are not likely to be confused."—Ulrich, *loc. cit.*

Richmond formation, Richmond, Indiana (Whitewater division).

ORTHODESMA CANALICULATUM Ulrich.

Plate XLVII, figs. 4-4b.

Orthodesma canaliculatum Ulrich, 1894, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 520, pl. xxxvii, figs. 7-11.

"Shell elongate, the length three times the hight; cardinal and basal margins straight, nearly parallel; posterior margin oblique, rounding into the hinge line, below which it slopes backward with a gentle curve to the postero-basal extremity where it turns abruptly into the basal line; anterior end contracted in front of the beaks, of moderate length, rounded, most prominent a little above the middle. In a side view the beaks project very little, are compressed by a broad shallow sulcus which crosses the valves and occupies a large part of the anterior three-fifths of the shell; umbonal ridge rather distinct, extending from the beaks to the postero-basal extremity. In a cardinal view of casts of the interior, the only condition in which the species has been noticed, the hinge line is strongly depressed, lying at the bottom of a wide and deep channel, deepest between the widely separated beaks and gradually shallowing posteriorly. Casts usually almost smooth, exhibiting only a small number of obscure concentric furrows. One specimen preserves a small part of the shell and this shows that near the dorsal edge the outer surface is marked with somewhat regular raised lines, about six of them in 5 mm. The best preserved casts exhibit in the posterior half of the mesial sulcus a number of obscure radii. Anterior muscular scar sharply defined at the inner side, rather small, broad-oval or circular, occupying the middle two-fourths of the upper half of the anterior end. Posterior impression somewhat larger than the anterior, subcircular, with a narrow prolongation extending forward nearly parallel with the posterior cardinal margin. Pallial line distinct in the anterior half, consisting (on the casts) of a straight row of obscure pustules extending in a slightly oblique direction from the base of the anterior adductor impression toward a point much nearer the ventral border.

"There are several peculiar features about this species. (1) I have never seen its valves separate, a fact indicating, if it is not fully accounted for by the next circumstance, a strong ligament. (2) Its natural position seems to have been with the anterior end down, and so it is commonly found in the shales, and in consequence is often greatly shortened by pressure. (3) The channel-like depression of the hinge; and (4) the unusual course of the anterior half of the pallial line. These peculiarities distinguish the species readily from all others of the genus known."—Ulrich, *loc. cit.*

Reported from the upper beds of the Cincinnati series in Ohio and Indiana (Ulrich).

ORTHODESMA RECTUM Hall and Whitfield.

Plate XLVII, figs. 6, 6a.

Orthodesma recta Hall and Whitfield, 1875, Pal. Ohio, II, p. 94. pl. ii, figs. 7, 8.

"Shell elongate, solen-like in outline, two and a half to three times as long as wide, the cardinal and basal lines posterior to the beaks straight and parallel; anterior end abruptly contracted beneath the beaks to one-half the width of the body of the shell, somewhat extended and abruptly rounded at the extremity; posterior end as broad as the body of the shell, obliquely rounded, longest at the postero-basal angle, and gently sloping backwards to the extremity of the hinge line; beaks small and compressed; surface of the valves between the umbonal ridge and the anterior contracted portion depressed, forming a broad, shallow, and undefined sulcus, strongest toward the beaks, and becoming obsolete or lost in the general flattening of the shell before reaching the basal line, in which it scarcely produces any perceptible feature.

"The surface of the valves is marked by irregular, concentric lines of growth, and by several stronger undulations, which become somewhat regular on the posterior slope for a short distance below the hinge line. There are also appearances of one or two obscure secondary ridges on the cardinal slope between the umbonal ridge and the cardinal margin, extending from near the beak to the posterior end of the shell. This latter feature is extremely faint, and may be often not observable.

"The species is not readily confounded with any other found in the same geological position, except, perhaps, *O. curvata,* from which it may be distinguished by the contraction of the basal line and the greater posterior breadth of the shell in that species. It somewhat resembles *Orthodesma parallela=Orthonota parallela,* Hall, Pal. N. Y., Vol. I, p. 299, pl. 82, fig. 7, from the Hudson River group of New York, but it differs in the greater contraction of the anterior end, the broader beaks, the broad, undefined depression of the median portion of the valves, and in the form of the posterior end of the shell, which in that species is rounded, while in this one it is obliquely truncate. The surface characters also differ very materially in the two forms, that one having fine, even, regular, concentric lines over the anterior two-thirds of the valves." —Hall and Whitfield, *loc. cit.*

The type is from the Richmond formation at Waynesville, Ohio. It is reported in Kindle's list from Madison, Indiana. I have not seen any specimens of it.

ORTHODESMA SUBANGULATUM Ulrich.

Plate XLVII, figs. 7, 7a.

Orthodesma subangulatum Ulrich, 1893, Geol. Ohio, VII, p. 660, pl. lv, figs. 21-23.

"This species is closely related to *O. rectum,* H. and W., the type of the genus, but may be distinguished by a number of minor differences, chiefly in the matter of outline. The shell is more elongate, the posterior height being less and only about one-third of the entire length. The ventral margin is straighter and sinuate rather than convex, while the central and dorsal outlines are more nearly parallel. The anterior end is uniformly rounded instead of being oblique with the most prominent point in the upper part. Finally, the posterior margin is a little more oblique. Of other differences we may mention that the umbones seem to have been somewhat smaller and merely flattened instead of sulcate, while the umbonal ridge is stronger and more curved.

"The Trenton species *O. subnasutum* (*Modiolopsis subnasuta,* Meek and Worthen), is higher posteriorly, while *O. curvatum,* Hall and Whitfield, has a more rounded posterior end and more sinuate ventral margin. None of the other species are near enough to require comparisons."—Ulrich, *loc. cit.*

Upper beds of the Cincinnati group, Richmond, Indiana.

ORTHODONTISCUS MILLERI Meek.

Plate XLVII, figs. 8-8c.

Anodontopsis ? milleri Meek, 1871, Amer. Jour. Sci., 3d ser. II, p. 297. (Not figured.)

"Shell ovate, rather compressed or only moderately convex, the greatest convexity being a little above and slightly in advance of the middle, extremities more or less narrowly rounded, basal margin longitudinally semi-oval in outline, the most prominent part being near the middle; cardinal margin sloping from the beaks at an angle of 130° to 135° and rounding into the lateral margins; beaks only moderately prominent, somewhat obtuse and not very convex, placed more than one-third the length of the valves from the anterior end. Surface smooth, or only with obscure lines of growth.

"Length of a medium sized adult specimen, 0.83 inch; height, 0.59 inch; convexity, 0.30 to 0.33 inch.

"It is not without considerable doubt that I refer this shell to McCoy's genus *Anodontopsis,* since it does not seem to correspond exactly in its hinge characters to his description of that genus, if I correctly understand him. As the hinge of *Anodontopsis*, however, has not yet been illustrated, and different authors do not always describe the same hinge exactly in the same way, I have concluded to refer our shell, for the present, provisionally to *Anodontopsis*. If a new genus, however, it may be called *Orthodontiscus*.

"Prof. McCoy described the hinge of his genus as follows: 'Hinge line shorter than the shell, with a posterior long slender tooth or cartilage plate extending just below it (double in the right valve), and another similar but shorter one in front of the beaks,' and then adds that there is 'occasionally one small cardinal tooth beneath the beak.'

"In the shell here described, the hinge may be characterized as having one rather well defined, subtrigonal, or somewhat obliquely extended cardinal tooth under the beak of the right valve, and a corresponding pit under the beak of the left valve, with sometimes a slight prominence or rudimentary cardinal tooth just in advance of this pit; while of posterior lateral teeth there is in the right valve one long tooth ranging parallel to the cardinal margin, with a parallel furrow above and below it for the reception of two posterior laters in left valve, the lower one of which is more prominent, and the upper merely linear or rudimentary. The furrow between these two posterior lateral teeth of the left valve is well defined, and receives the tooth between the two furrows in the other valve. Below the lower of these furrows on the posterior side of the right valve, there is a very slight marginal ridge, that may sometimes assume the character of a second posterior lateral, but it is most prominent anteriorly, where it connects with the cardinal tooth, of which it seems to be rather an oblique posterior prolongation than a distinct tooth. On the anterior side there is one shorter anterior lateral tooth in the right valve, also ranging parallel to the hinge margin, and above and below this a little furrow for the reception of two small anterior laterals in the left valve, which receive between them that of the right valve.

"The pallial line is certainly simple, and the muscular impressions well defined, the posterior one being larger than the other, and provided with a small accessory scar above just under the posterior ends of the posterior lateral teeth. The ligament or cartilage was probably small and internal, as there are no traces of an external ligament to be seen, the valves fitting close all along the hinge margin. No lunule or escutcheon is to be seen in any of the specimens.

"The specific name is given in honor of S. A. Miller, Esq., of Cincinnati, Ohio, who sent on to the Smithsonian Institute the first specimens of this shell I have seen. I am also indebted to him for some broken valves showing the hinge. For the use of a good specimen showing the hinge of the left valve I am likewise under obligations to C. B. Dyer, Esq., of Cincinnati."—Meek, *loc. cit.*

This shell is said by Meek to come from forty miles west of Cincinnati, from above the middle beds of the Cincinnati group. In Kindle's list it is said to come from Versailles, which would make it a Richmond group form.

ORTONELLA HAINESI (Miller).

Plate XLVII, figs. 9-9d.

Cypricardites hainesi Miller, 1874, Cincinnati Quartely Journal of Science, I, p. 147, figs. 12, 13.

"Equivalve, inequilateral; margins subparallel, diverging posteriorly; beaks sharp, projecting over the hinge line and slightly incurved; umbones subangular, with a ridge extending posteriorly and curving toward the base, where it becomes obsolete; cardinal teeth unknown; lateral teeth two, one much longer than the other; muscular impression below the beak anteriorly.

"The cardinal teeth, in the valve, figure 13 [of Miller's paper], being destroyed, as shown by the letter *t*, the number and character could not be ascertained.

"Surface marked by fine concentric lines.

"Length 1 3/20 inches; width, 19/20 inch; greatest depth through the umbones 12/20 inch.

"The specific name is given as a compliment to Mrs. M. P. Haines, an earnest and devoted naturalist of Richmond, Indiana, who has collected a very fine cabinet and studies to appreciate it."—Miller, *loc. cit.*

From what Miller says about the locality at which this species was found, it would correspond to some portion of the Whitewater division. Ulrich says it is found associated with *Rhynchotrema dentata* about forty feet below the top of the Richmond formation (Whitewater division).

PTERINEA CORRUGATA (James).

Avicula corrugata James, 1874, Cincinnati Quarterly Journal of Science, I, p. 239. (Not figured.)

"Shell (left valve) oblique, subrhomboidal; cardinal line greater than the breadth of the shell farther forward; umbone prominent; beak compressed; anterior ear rounded on a line with the margin of the shell; posterior ear triangular, extending beyond the margin below. Anterior umbonal slope abrupt; posterior slope gradual to the point of the ear and the back margin. Surface marked by crowded concentric lines of growth, strongly corrugated from the umbone to the front, giving to that part of the surface a finely sculptured appearance, but not extending to the wings or ears.

"Breadth, measuring along the cardinal line, about one inch; length from the back obliquely to the front, seven eighths of an inch."—James, *loc. cit.*

Reported by James from the Richmond formation in Wayne County, Indiana (Richmond?).

PTERINEA DEMISSA (Conrad).

Plate XLVIII, fig. 1.

Avicula demissa Conrad, 1842, Jour. Acad. Nat. Sci. Philadelphia, VIII, p. 242, pl. xiii, fig. 3.

"Elevated; inferior valve plano-convex, concentrically wrinkled, and occasionally slightly furrowed; anterior wing triangular, the upper margin on a line with that of the posterior wing, which is extended beyond the line of the posterior extremity; beneath the wing the posterior margin is nearly straight, and but slightly oblique; upper valve flat, and concentrically furrowed with wide, shallow, concave grooves; summit of umbo on a level with the hinge line."—Conrad, *loc. cit.*

Hinge line much longer than the body of the shell. Anterior wing extended, when perfect, into a rather long acute point, forming nearly one-third of the length of the hinge, measured from the point of the beak. Posterior wing large, rather obtusely pointed, and extending as far as the body of the shell below; a line drawn from the beak to the center of the base forms an angle of about 65 or 70 degrees with the posterior hinge line. Left valve strongly convex; right valve concave. (Meek.)

1.41A6, 7, 10b, B1, D1, 3, C2-3, E1....1.12E3, F3.

PTERINEA INSUETA (Emmons).

Plate XLVIII, fig. 2.

Avicula insueta Emmons, 1842, Geol. New York, Rep. Second Dist., p. 399, fig. 110, No. 5.

"No. 5. *Avicula insueta,* belongs to the Mohawk valley. I did not find it in the slate of the Second district."—Emmons, *loc. cit.*

This shell is reported from Madison by Cornett, but quite certainly does not occur there or anywhere else in the Cincinnati group.

RHYTIMYA BYRNESI (Miller).

Plate XLVIII, figs. 3-3a.

Orthodesma byrnesi Miller, 1881, Jour. Cin. Soc. Nat. Hist., IV, p. 76, pl. I, figs. 7-7b.

"Shell of medium length and breadth, but proportionally very thin. Cardinal and basal margins sub-parallel, but gradually diverging posteriorly to the posterior third of the shell. The cardinal line is straight, posterior to the beaks, for about one third of the length of the shell, from which point it gradually declines to near the extremity, which is abruptly rounded. Anterior end contracted beneath the beaks, and beautifully rounded in front. Basal line concave in the middle part, for about one half the length. Beaks small but nearly or quite uniting; umbones flattened, and, from which, there is a shallow expanding depression, directed a little posteriorly, and crossing the valves to the basal line.

"Surface of the valves marked by concentric lines, and covered by numerous little spines.

"Length, 1 2-10 inches; height, 5-10 inch; thickness, 25-100 inch.

"This species is founded upon a specimen preserving the shell, and also upon the matrix from which the shell was taken, collected by Dr. R. M. Byrnes, in whose honor I have given the specific name, in the upper part of the Hudson River group, near Weisburg, Indiana, and now belonging to his collection. It is peculiar in preserving the markings of the spines which covered the surface, in the matrix, and also preserving the bases of them on the shell, which may be readily observed with an ordinary magnifier. It will be distinguished from other species by the fact that its thickness is only half its height, and only one fifth its length, as well as by other peculiarities. As this species was covered with numerous spines, it becomes interesting to know whether other species in the same genus were also thus ornamented."—Miller, *loc. cit.*

Richmond formation, Weisburg, Indiana.

SEDGWICKIA FRAGILIS Meek.

Plate XLVIII, figs. 4, 4a.

Sedgwickia ? fragilis Meek, 1872, Proc. Acad. Nat. Sci. Phila., 1872, p. 323. (Not figured.)

"Shell rather small, apparently very thin, longitudinally oblong or suboval, rather distinctly convex along the umbonal slopes from the beaks toward the posterior basal margin, and down near the anterior side, while just under the beaks a rather strongly marked impression descends, widening and deepening as it approaches the base; basal margin subparallel in its general outline to the dorsal, but diverging more or less posteriorly, where it is most prominent and distinctly sinuous toward the front; posterior margin wider than the anterior, and more or less truncated; anterior extremity very short, and rounded or somewhat truncated; hinge line straight, and shorter than the entire length of the valves, apparently very slightly inflected behind the beaks, which are raised a little above the cardinal margin, incurved, contiguous, flattened on the outer sides, and placed near the anterior end, with a slight forward inclination. Surface ornamented with moderately distinct lines and irregular minute wrinkles of growth.

"The only specimens of this species yet known to me are too imperfect to afford exact measurement, though they seem to have been, when entire and undistorted, about 0.90 inch in length, 0.73 inch in height, and 0.40 inch in convexity. They present some appearance of having been gaping behind and in the anterior ventral region. One specimen looks as if it had been truncated, with a backward obliquity from below upward behind, but this may be due to distortion.

"I am far from being satisfied that this shell is congeneric with the forms for which Prof. McCoy proposed the name *Sedgwickia,* as nothing can be determined from the specimens yet known in regard to its hinge and muscular and pallial impressions. Possibly it would be nearer right to call it *Modiolopsis fragilis*; but there is something in its physiognomy that suggests affinities to Carboniferous types referred to *Sedgwickia* and *Allorisma.*"—Meek, *loc. cit.*

Doubtfully reported from Madison, Indiana.

The type is from 350 ft. above low water mark at Cincinnati, Ohio.

SPHENOLEUM RICHMONDENSE Miller.

Plate XLVIII, fig. 5.

Sphenoleum richmondense Miller, 1889, North American Geology and Paleontology, p. 513, figs. 925, 926.

"Shell large, cuneiform, ventricose, beaks incurved at the anterior end, pointed; umbones high, defined; cardinal line at a high angle, having a wing-like posterior end; anterior end rounded below the lunule. Distinguished from S. cuneiforme, which it much resembles, by its shorter form and more angular umbones. Possibly more specimens may show a gradation from one form to the other, and if so, this specific name will fall into the synonomy. Collected by Charles Faber in the upper part of the Hudson River group, at Richmond, Indiana."—Miller, *loc. cit.*

TELLINOMYA HILLI Miller.

Plate XLVIII, fig. 6.

Tellinomya hilli Miller, 1874, Cincinnati Quarterly Journal of Science, I, p. 230, fig. 20.

"Shell somewhat oval in outline, the posterior end prolonged, with the cardinal border nearly straight, until it bends somewhat circurlarly to the point of greatest extension; anterior end quite regularly rounded; basal margin forming a semi-elliptic curve; beaks near the anterior end moderately prominent, greatest convexity immediately behind the beaks; surface smooth. Hinge line occupied by three small teeth anterior to the beak and ten small teeth posterior to it. Some difficulty has been experienced in determining the number of teeth from their indistinct character in the specimen examined, and it may be that there are actually more than we have stated. Muscular impressions and pallial line not observed.

"The very slight curvature of the hinge line and the minute character of the teeth, as well as their straight transverse character, may leave some doubt as to whether or not this shell belongs to the genus *Tellinomya*.

"The specific name is given in honor of Dr. H. H. Hill, of Cincinnati, who has been an active collector in various departments of natural history for a number of years, and very prominent in the organization and management, from the beginning, of the Cincinnati Society of Natural History. His private cabinet sparkles with mineral gems, is ornamented with the rarest and finest specimens of the workmanship of the Indians and Mound Builders, and bears upon its shelves many of the choicest fossils of the Cincinnati group.

"I found this species in the upper 50 feet of the Cincinnati group, about three miles south of Osgood, Indiana, and nearly fifty miles west of Cincinnati. The valves were found quite abundant, though not well preserved, on slabs, associated with *Beyrichia striato-marginatus*. An entire specimen was not found."—Miller, *loc. cit.*

Imperfect specimens in the writer's collection may belong to this species. Saluda.

WHITEAVESIA CINCINNATIENSIS (Hall and Whitfield).

Plate XLVIII, figs. 7, 7a.

Modiolopsis cincinnatiensis Hall and Whitfield, 1875, Pal. Ohio, II, p. 88, pl. ii, figs. 14, 15.

"Shell of medium size or smaller; elongate ovate, or narrowly sub-elliptical in outline; widest posteriorly, and abruptly contracted in front of the beaks; hinge line slightly arcuate, and a little more than half as long as the shell posterior to the beaks; posterior margin obliquely sloping, with a slight convexity, from the extremity of the hinge line to the postero-basal angle, which is the point of greatest length of the shell. Basal line gently curving throughout its length in most cases, but in some examples becoming slightly sinuate opposite or a little posterior to the beaks. Anterior end narrow, not very extended, and sharply rounded. Beaks small, appressed; projecting but little above the hinge line, and situated just within the anterior third of the length of the shell. General surface of the shell moderately convex; most prominent along the posterior umbonal ridge, which is sharply rounded or obscurely angular; umbonal slope abrupt and slightly convex. An obscure, shallow mesial depression extends across the valves from the beaks, reaching the basal line just behind the anterior third of the length.

"Surface marked by numerous, irregular, concentric lines of growth, which are often strongly marked, but without any definite arrangement; a little stronger on the anterior portion of the shell than elsewhere. The substance of the shell is thin, and the surface, when perfect, quite polished.

"This species bears considerable resemblance to the larger specimens of the form identified with and figured as *M. anodontoides,* Conr., in Paleontology of New York, Vol. I, p. 298, pl. 82, fig. *3b,* but differs in the greater breadth posteriorly, and in being much contracted in width in front of the beaks. From the other forms given on the same plate as the same species it differs more strongly, and can not be readily confounded with them. The specimen represented by fig. *3a* of the same plate, which is the original of the species used by Mr. Conrad for description, and that which must be considered as possessing the true specific characters, is much more angular along the umbonal ridge; the hinge line is proportionally longer, and the anterior end of the shell shorter and broader than in the species under consideration."—Hall and Whitfield, *loc. cit.*

Reported by Hall and Whitfield from near the base of the Cincinnati formation at Cincinnati, Ohio; and in Kindle's list from Richmond, Indiana. It almost certainly does not occur in the Richmond formation.

WHITEAVESIA PHOLADIFORMIS (Hall).

Plate XLVIII, fig. 8.

Modiolopsis pholadiformis Hall, 1851, Report on the Geology of the Lake Superior Land District, p. 213, pl. xxx, figs. 1 a-c; pl. xxxi, fig. 1.

"Shell oval-obovate, elongate; base slightly arcuate in the middle; convex in the middle and compressed towards the posterior extremity; umbones prominent, hinge-line slightly arched, and, in some specimens, nearly straight; muscular impression large and strong, near the anterior extremity; surface marked by strong folds or ribs, which, originating on the hinge-line, diverge and curve gradually downward to the base.

"All the specimens of this peculiar species, which I have examined, are more or less distorted, so that we may not be fully acquainted with the form. The peculiar surface-marking, however, is unmistakable, and in nearly all the specimens is preserved, in some degree, even in casts. There appears to be considerable difference in the size of these ribs in different specimens, and it is possible that we have among them two species, which, for the present, however, we prefer to regard as one. The form in many specimens is similar to that of *M. modiolaris,* but in the surface-markings it is very distinct. In some specimens, however, from the same locality, which appear to belong to *M. modiolaris,* I have observed concentric ribs similar to those in the species now described. In that species, however, they appear more arched, and confined to the region of the hinge-line, gradually losing themselves in the concentric striae, and are quite obsolete toward the base. Nevertheless, we have never observed this feature in the New York specimens, and these western ones, thus marked, prove a distinct species.

"*Geological Position and Locality.*—This species occurs in the marly beds, constituting the higher portions of the Hudson-river group, on the eastern shore of Little Bay des Noquets. It is associated with *M, modiolaris* and *Ambonychia radiata,* with two or three species of Orthoceratites."—Hall, *loc. cit.*

Reported by Miller from Richmond, Indiana.

WHITELLA OBLIQUATA Ulrich.

Plate XLVIII, figs. 10-10d.

Whitella obliquata Ulrich, 1890, Am. Geol., VI, p. 177, 178, fig. 13 a-e.

"Shell large, oblique, subrhomboidal in outline, produced in the postero basal region, ventricose, with point of greatest convexity above the middle; beaks rather small, prominent, slightly incurved, situated one fourth of the length of the hinge line from its interior extremity, umbonal ridge well marked, the cardinal slope concave. Anterior end small, narrowly rounded above, merging gradually into the evenly and only moderately convex ventral margin. Posterior end sharply curved and produced below, gently convex and sloping forward in the upper half to meet the slightly convex, cardinal margin. Escutcheon well marked, wide, shallowest in front of the beaks. Anterior muscular scar elongate. Hinge thin, the posterior half simple, the anterior half, of the left valve, with two long slightly oblique teeth just beneath the beak, and two shorter parallel ones at the anterior extremity.

"The dimensions of cast of the interior, of the average size, are as follows: greatest length 50 mm.; greatest hight 38 mm.; greatest convexity 24 mm. A large specimen is 59 mm. long, and 42 mm. high.

"This species is related to *W. sterlingensis* (*Dolabra sterlingensis, M. and W.*) but has a longer hinge line, is less convex, wider posteriorly, and more oblique, the angle included between the hinge line and the umbonal ridge being much narrower. *W. hindi* (*Cyr-*

todonta hindi Billings) is much more acutely produced posteriorly, being besides on the whole a more elongate shell, with the umbones also more tumid."—Ulrich, *loc. cit.*

Ulrich reports this shell from the upper beds of the Cincinnati group at several localities in Indiana and Ohio.

WHITELLA UMBONATA Ulrich.

Plate XLVIII, figs. 9-9c.

Whitella umbonata Ulrich, 1890, Am. Geol., VI, p. 178, figs. 14 a-d.

"A detailed description of this species is scarcely necessary, since the main point in identifying it is to distinguish from *W. obliquata*. On comparison it will be found that the beaks and umbones are much larger than in that species, the postero-dorsal slope shorter and more abrupt, the hight comparatively greater and the outline in general somewhat different, particularly in the ventral region where the margin is more convex than in *W. obliquata*. *W. quadrangularis* (*Cypricardites quadrangularis* Whitfield) is much shorter and more erect.

"In a large specimen the hight and length are respectively 47 mm. and 60 mm.; in a small specimen 38 mm. and 45 mm.; greatest convexity of the latter 25 mm."—Ulrich, *loc. cit.*

This species is reported by Ulrich as occurring at Blanchester, Middletown and other localities in Ohio and Indiana, in the upper beds of the Cincinnati group (Richmond).

CEPHALOPODA.

DIAGNOSES OF GENERA.

The generic disposition of the species of Cephalopoda described in this report is, it must be confessed, unsatisfactory. Nevertheless, I do not see how they can well be placed in the various genera erected by Hyatt, until very much further study has been devoted to them with special reference to the young stages of growth; and just at present the material is not available for such studies. This is especially true of the species referred to the genus *Orthoceras,* since most of them are founded on fragments which lack the critical characters that might enable one to place them in their proper genera. As restricted by Hyatt *Orthoceras* is not an Ordovician genus; nevertheless I believe it is better for the present to leave the species from the Cincinnati group, which have ordinarily been referred to that genus, where they are, awaiting a final revision when adequate material is at hand. In the case of the species which is identified with *Cameroceras proteiforme,* if it is that species, I believe we should recognize the distinctions insisted upon by Hyatt and place the form in the genus *Endoceras,* as restricted by that author. I have accordingly disposed of it in that way.

CYRTOCERAS Goldfuss.

Shell long, conical, gently curved, aperture sometimes contracted; siphuncle straight or expanded between the septa, and variable in position, but usually at the outer edge. (Miller.)

ENDOCERAS Hall.

Smooth or annulated orthoceracones. Funnels reaching from septum of origination to the next apicad of this, but no farther. Septa pass entirely around the siphuncle. Organic deposits in the form of endocones, and taper off at the center into a spire that is sometimes tubular and hollow, or again flattened and elliptical. This is the *endosiphuncle.* (Hyatt.)

GOMPHOCERAS Sowerby.

Stout short orthoceracones and cyrtoceracones similar to some species of *Phragmoceras,* but straighter, stouter, and less compressed in form, and gerontic aperture less contracted laterally. Hyponomic sinus shorter, and curvature exogastric. (Hyatt.)

GYROCERAS DeKonink.

Discoid, rolled in one plane; volutions in contact or open, but not embracing; transverse section circular, elliptical, scutiform, or polygonal; body chamber large and sometimes straight or tangent to the spiral; opening hollowed out on the exterior border like the Nautilus; septa arched and frequently project, curving backward; siphon slender, cylindrical, and usually subcentral toward the convex border, but sometimes found within the concave border; surface tuberculous, having imbricating excrescences or ringed with projecting fringes from the septa. (Miller.)

ORTHOCERAS Breynius.

Shell conical, straight, or nearly so; body chamber large, behind which the shell is composed of numerous chambers separated by convex, transverse septa, with simple edges, at right angles to the longer axis of the shell; siphuncle central, subcentral or eccentric, cylindrical or dilated in the chambers; surface smooth or transversely or longitudinally striated, or furrowed. (Miller.)

DESCRIPTION OF SPECIES.

CYRTOCERAS AMOENUM Miller.

Plate XLIX, fig. 1.

Cyrtoceras amoenum Miller, 1878, Jour. Cin. Soc. Nat. Hist., I, p. 105, pl. iii, fig. 8.

"Shell large, gently arched, and very gradually tapering; section slightly elliptical, the dorso-ventral diameter being a little more than the transverse. Body chamber contracted toward the front. Septa moderately arched. In the specimen figured, the body chamber is followed by six thin chambers before reaching what appear to represent the mature size; another specimen shows only five of these thin chambers between the body chamber and the mature sized shell chambers. Where on the back of a shell the septa are nearly 2-10ths of an inch distant, the transverse diameter of the shell 1 3-10ths inches, and the dorso-ventral diameter 1 5-10ths inches. Measuring on the side, however, the transverse diameter of the shell is equal to the thickness of almost nine shell chambers. Siphuncle small, and situated very close to the margin on the dorsal or outer side of the shell. Outer shell and surface unknown.

"The specimen illustrated has a dorso-ventral diameter of 1 4-10ths inches, and transverse diameter a little over 1 2-10ths inches. It contains twenty-three chambers, including the thin ones, between the body chamber and the broken end in a length of 2½ inches.

"I collected the specimens at Richmond, Indiana, in the upper part of the Cincinnati group, and near the top of the bluffs which abut the river."—Miller, *loc. cit.*

Whitewater.

CYRTOCERAS HALLIANUM d'Orbigny.

Cyrtoceras halleanus d'Orbigny, 1850, Prodrome de Paleontologie, I, p. 1. (Not figured or described.)

"9. Halleanus, d'Orb., 1884, *C. lamellosum,* Hall, 1847. Palaeont. of New-York, t. I, p. 193, pl. 41, fig. 2 (non Verneuil, 1842). Etats-Unis, New-York, Trenton-limestone."—d'Orbigny, *loc. cit.*

This species reported in Kindle's list as occurring at Madison, Indiana (on the authority of Cornett), is not a Cincinnati group species.

CYRTOCERAS TENUISEPTUM Faber.

Plate XLIX, figs. 2, 2a.

Cyrtoceras tenuiseptum Faber, 1886, Jour. Cin. Soc. Nat. Hist., vol. IX, No. 1, p. 18, pl. i, figs. 3 a-c.

"Specimen medium size, with slight curvature and tapering very slightly. Composed of twenty thin septa, equal in width and rather circular in section. Siphuncle small and dorsal. Specimen is thirty two *mm.* in length, and measures in section seventeen *mm.* in its greater, and fifteen *mm.* in its lesser diameter.

"3a is a dorsal view of a larger specimen of the same species, having five septa and a body-chamber showing the sinus. The body-chamber is 27 *mm.* in length, and measures in section 23 *mm.* in its greater, and 20 *mm.* in its lesser diameter. This specimen has a thick shell, but shows no external markings. It also shows that a coral had begun its growth in the body-chamber and extended somewhat beyond it. This species has about seventeen septa to an inch. 3a is a remarkable specimen, as it is the only one figured and known to me of this group with a complete body-chamber.

"Collected by the author in the Cincinnati group near Waynesville, O., and at Versailles, Ind."—Faber, *loc. cit.*

CYRTOCERAS THOMPSONI Miller.

Plate XLIX, Figs. 3, 3a.

Cyrtoceras thompsoni Miller, 1893, Geol. Nat. Hist. Indiana, vol. XVIII, p. 323, pl. x, figs. 7, 8.

"Shell medium sized, rather rapidly increasing in size and slightly but regularly curved; transverse diameter one-fifth greater than the dorso-ventral; broadly rounded on the dorsal and ventral sides and more narrowly rounded on the lateral sides; transverse section elliptical.

"Septa very slightly arched, almost transverse in the young shell and distant from each other in the younger shell about one-tenth the transverse diameter, but nearer the body chamber in maturer shells about one-twelfth the transverse diameter; siphuncle very small and close to the outer margin. Outer shell thin and smooth or marked by fine transverse lines of growth, of which there is some evidence on the specimen described.

"Our specimen is from the middle part of the shell and shows no part of the body chamber. Part of the outer shell is quite well preserved. It will be distinguished from other species by the transverse elliptical section, close septa and gentle curvature.

"Found in the Hudson River Group, at Longwood, Fayette County, Indiana, and now in the collection of A. C. Benedict. The specific name is in honor of Prof. Maurice Thompson, late State Geologist of Indiana."—Miller, *loc. cit.*

ENDOCERAS PROTEIFORME Hall.

Plate L, figs. 1-1d.

Endoceras proteiforme Hall, 1847, Pal. New York, I, p. 208, pls. xlv, to l. and liii.

"General form cylindrico-conical, more or less elongated, often compressed, tapering somewhat unequally in different specimens; young specimens terminating in an extremely acute point; surface marked by distinct transverse striae, which usually appear like narrow subimbricating bands, with one edge well defined and more elevated than the other, more or less distinctly striated longitudinally; striae varying from extreme tenuity to distinct elevated thread-like lines; section circular; septa distant from one fifth to one fourth the diameter; siphuncle eccentric or submarginal.

"I am able to characterize three distinct varieties of this species, which are the prevailing forms; these depend mainly on the surface markings of the young shell. The old shells are recognized by a large submarginal siphuncle, which usually contains a smooth cylindrico-conical embryo tube or sheath. This tube is sometimes irregularly tapering, and always free from visible surface markings or sculpture. Within this embryo tube are the young shells, sometimes perfectly formed Orthocerata, and at other times destitute of septa or siphuncle. These young shells are also frequently found separate from the parent shell or embryo tube, when we are compelled to rely upon the surface markings for their determination. The position of the sipuncle, convexity of septa, and some other characters, are usually constant in all the varieties, which only exhibit a change in the character of the surface. In the absence of septa and siphuncle, which is of common occurrence in the young shell, the character of the surface is reliable for determining the species.''—Hall, *loc. cit.*

The characters of this species are better indicated by Hall's figures, which I reproduce, than by the above description, which is rather vitiated by the fact that these fossils were not thoroughly understood at that time. The great siphones of these huge Cephalopods, as remarked by Clarke, were favorite retreats for other species of Cephalopods, and to such adventitious species belong the so-called young shells mentioned by Hall, and upon which he based several of his varieties. The specimens that have come under my notice in Indiana are all of rather small size, as compared with the immense size of some of the examples known from the New York formations. They seem to have all the characters of *E. proteiforme,* however, aside from size, and I see no reason for making any other disposition of them.

All of my specimens, which are imperfect fragments, are from the Richmond formation.

1.34A17, 19....1.41A9.

GOMPHOCERAS INDIANENSE Miller and Faber.

Plate XLIX, figs. 4-4b.

Gomphoceras indianense Miller and Faber, 1894, Jour. Cin. Soc. Nat. Hist., vol. XVII, p. 137, pl. vii, figs. 3, 4, 5.

''Shell medium or a little above medium size. Transverse section ovate. Ventral or narrow side of the ovate outline nearly straight, while the opposite or dorsal side is strongly arched from the apex to the mouth. Body chamber forming nearly half the length of the shell; the specimen illustrated has part of the tenth air chamber, and another specimen has part of the eleventh air chamber preserved, and apparently it approximates close to the apex. Probably, if complete, these specimens would not have more than thirteen or fourteen air chambers. Septa moderately concave, the concavity not amounting to the depth of an air chamber, and almost equally distant from each other, from the apex to the body chamber. The increase in the diameter of the shell is not followed with a corresponding increase in the distance of the septa from each other, or in the length of the air chambers. The sutures curve forward over the dorsal or convex side of the shell. The greatest transverse diameter is in the lower half of the body chamber. The siphuncle is marginal on the straight or ventral side, and abruptly expands in the cavities of the short air chambers to two and a half or three times its diameter at the septa. The aperture is unknown.

"The external shell is thin, transversely wrinkled and smooth. The surface being smooth, the transverse wrinkles do not appear as lamellose lines of growth, nevertheless the wrinkles may mark stages of growth in the shell, though they do not conform to the septa or sutures.

"This species does not resemble *Gomphoceras eos* from rocks of about the same geological age. *Gomphoceras eos* is longitudinally ovoid, but not transversely ovoid. This species is not longitudinally ovoid, for the lateral sides are flattened, the ventral side nearly straight or slightly convex and the dorsal side convex, but transversely it is more or less ovoid. *Gomphoceras eos* has proportionally a much shorter and more robust body chamber, more numerous air chambers and more arcuate septa, and the siphuncle is eccentric in the middle of the greater diameter of the shell. We have a good specimen of *Gomphoceras eos,* having eight body chambers, and will give some measurements for comparison. The body chamber is 1 85/100 inches long; 2 60/100 inches in diameter dorso-ventrally or through the siphuncle; and 3 20/100 inches in diameter laterally; the length of the air chambers is 1 65/100 inches, making the total length of the entire specimen 3 50/100 inches; the lateral diameter of the last or eighth air chamber is 2 10/100 inches, and dorso-ventrally nearly 2 inches, though it is broken on the siphuncular side so the latter measurement is not accurate. The specimen illustrated has a body chamber 1 80/100 inches long; 2 80/100 inches in diameter dorso-ventrally; and only 2 inches in diameter laterally; the length of the two specimens does not differ very much; but the eighth air chamber in the specimen illustrated has a dorso-ventral diameter of 1 80/100 inches and a lateral diameter of only 1 40/100 inches. The outer shell and aperture of *Gomphoceras eos* are unknown, but our cast shows a deep notch at the ventral side of the aperture, which indicates that the species here described is not congeneric with it.

"Mr. Faber collected three specimens of this species, one of which is illustrated, in the upper part of the Hudson River group, near Versailles, Indiana, and Prof. Hubbard and Mr. J. F. Hammel collected a number of specimens in the same range, associated with *Cyrtocerina madisonensis,* near Madison, Indiana."—Miller and Faber, *loc. cit.*

I have specimens from the Richmond formation on Tanner's Creek, too imperfect for certain identification, that may belong to this species.

GYROCERAS BAERI (Meek and Worthen).

Plate LI, fig. 1.

Trochoceras ? baeri Meek and Worthen, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 263. (Not figured.)

"Shell subdiscoidal, consisting of about two or three rather rapidly enlarging volutions, which are more broadly rounded on the outer surface than on each side, and about one-fourth wider transversely than their dorso-ventral diameter; each inner whorl slightly impressing the inner side of the succeeding turn. Umbilicus a little more than half the dorso-ventral diameter of the outer volution, and showing all the inner volutions. Spire apparently scarcely rising above the upper surface of the last turn. Septa rather distinctly concave on the side facing the aperture, separated on the outer side of the whorls, at a point where the dorso-lateral diameter is about 1.25 inches, by spaces measuring 0.35 inches—all showing a very slight backward curve on the rounded periphery, and passing nearly straight across each side. Surface, siphon, and non-septate portion of the shell unknown.

"Greatest breadth of the septate part of the shell, 5 inches; height (estimated), about 2.50 inches. Dorso-ventral diameter of the volutions, increasing about three-fold each turn.

"The specimen from which this description was drawn up is defective on one side, so that it is not easy to determine whether or not its whorls are coiled in the same plane, though they have the appearance of being somewhat oblique, and hence we have placed it provisionally in the genus *Trochoceras.* Should it be found, however, when more nearly entire specimens can be examined, that its whorls are coiled all upon the same plane, it would belong either to the genus *Lituites* or *Nautilus,* and hence its name would become *Lituites Baeri,* or *Nautilus Baeri.*

"The typical specimen does not show the position of the siphon, but a fragment found near the same locality, and at the same horizon, apparently of this species, though possibly belonging to another shell, has the siphon placed about its own breadth outside of the center. It pierces the septa from without inwards or backwards, as in *Nautilus.*

"At a first glance this shell would seem to resemble *Cryptoceras* (*Lituites*) *undatus,* as represented by fig. 3, pl. 13, vol. i. Palaeontology of New York, but on a closer inspection it will be at once seen to differ materially in the more rapid increase in the breadth of its whorls, and in the proportionally smaller size and greater depth of its umbilicus, as well as being apparently not coiled on a plane.

"The specific name is given in honor of Dr. O. P. Baer, of Richmond, Indiana, to whom we are indebted for the use of the typical specimen."—Meek and Worthen, *loc. cit.*

The type is from the Richmond formation at Richmond, Indiana.

ORTHOCERAS BILINEATUM Hall.

Plate LI, figs. 2-2b.

Orthoceras bilineatum Hall, 1847, Pal. N. Y., vol. I, p. 199, pl. xliii, figs. 2 a-d.

"General form cylindrical, gradually tapering, marked by slightly arched or undulating rounded annulations distant about two fifths the diameter; surface marked by longitudinal sharp elevated lines, which alternate with finer lines in equal number; transversely marked by fine scarcely visible striae, which are interrupted by the longitudinal lines; section circular; siphuncle eccentric.

"Two series of longitudinal lines, one being more than twice the elevation of the other, are distinguishing features of this fossil. The annulations are more arched on the back than in the last species [*O. textile*], but still rounded. The transverse fine striae, under the magnifier, give a kind of varicose appearance, being closely arranged and slightly arched between the longitudinal ones, following the oblique direction of the annulations. The difference in the size of the longitudinal and transverse lines is a striking peculiarity of the species, rendering it readily distinguishable from the last."—Hall, *loc. cit.*

Hall's types are from the lower shaly strata of the Trenton limestone at Middleville, Turin and Lowville, New York. The species is reported in Kindle's list from Madison, Indiana, but it very probably does not occur in the Cincinnati series.

ORTHOCERAS BYRNESI Miller.

Plate LI, fig. 4.

Orthoceras byrnesi Miller, 1875, Cincinnati Quarterly Journal of Science, II, p. 126, fig. 13.

"Shell medium size, very long, and slowly tapering; arch of the chambers about equal to the distance between the septa, and distant about one seventh the diameter of the shell; siphuncle eccentric or crossing from one side to the other, and consisting of a series of slightly ovate enlargements in each chamber. The greatest diameter of the siphuncle is as much or a little more than the distance between the septa, while the septa are pierced with holes about two thirds the diameter of the siphuncle.

"The distance between the septa does not always increase uniformly, as the shell enlarges its diameter, but take a large number of chambers and the increased distance between the septa becomes manifest. It is likely that the increased distance between the septa is more uniform in rapidly tapering shells than in the longer and more slowly changing ones.

"Found on the hills back of Cincinnati; range unknown.

"Specific name given in honor of Dr. R. M. Byrnes, of Cincinnati."—Miller, *loc. cit.*

On the basis of strong similarity of the longitudinal section to that figured by Miller, I have referred a specimen from Manchester Station, Indiana, from the upper part of the Lorraine to this species. I admit that from the imperfect nature of the specimen the identification is worth very little.

ORTHOCERAS CARLEYI Hall and Whitfield.

Plate LII, fig. 1.

Orthoceras carleyi Hall and Whitfield, 1875, Pal. Ohio, II, p. 98, pl. iv, fig. 19.

"Among the fossils received for examination from the Hudson River formation there is a very interesting specimen of *Orthoceratite,* which does not appear to belong to any described species, but is in such a state of preservation as to present but few distinguishing features. Still, the conditions under which it presents itself are of such a nature as to make it one of considerable interest. The specimen consists of an inner septate tube of a little more than five inches in length, with a diameter at the lower end of about three-eighths of an inch, by about seven-eighths of an inch at the upper end, giving an increase of half an inch in the length of five inches, or one-tenth of the length. This tube is surrounded by two others, one within the other; each of the three being separated by a space of about an eighth of an inch on either side, giving to each about the same degree of expansion. The spaces between the tubes are filled with sedimentary matter; that between the inner and middle tube being composed chiefly of finely comminuted organic remains, while that between the two outer tubes is composed of fine silt chiefly, and in some places of crystalline matter. The septa of the inner tube are closely arranged, eight of the spaces measuring one inch where the upper end of the space measured is seven-eighths of an inch in diameter, those below being a little closer. These are all either empty spaces, or filled only by crystalline matter. There is not the least evidence of septa or partitions of any kind across the spaces between the several tubes. The specimen lies imbedded in the rock, and weathered away to near the center of its diameter, but the section at the end shows that the inner tubes rest upon, or nearly upon, the inner surfaces of the surrounding ones, as though they had settled to this position after they had been imbedded in the sediment. These conditions would seem to indicate that there had been no very intimate connection between the several tubes, and that the spaces between the outer ones and the inner septate portion had been open to the access of foreign matter, while the inner septate portion had been closed, or that the outer tubes had been independent of each other, and of the inner ones, and had only drifted into each by accident. If this has really been the case, these outer tubes must be only the terminal chamber or chambers of habitation, and must have been of unusual length, as the degree of tapering would carry the middle tube to within a few inches, if perfect at the lower end, of the point of a specimen nearly or quite fifteen inches in length. The probability, however, is that they are only fragments of outer chambers that have drifted upon the inner ones by accident.

"The first sight of the specimen might be taken for a beautiful example of the genus *Endoceras*; but true examples of this genus are septate in the outer tubes, while the inner ones are free from septa. The reverse is, however, the case in the example before us." —Hall and Whitfield, *loc. cit.*

The type is from the Richmond formation at Fayetteville, Brown County, Ohio. I am very uncertain about its occurring in Indiana.

ORTHOCERAS DUSERI Hall and Whitfield.

Plate LII, figs. 2-2b.

Orthoceras duseri Hall and Whitfield, 1875, Pal. Ohio, II, p. 97, pl. iii, figs. 2-4.

Shell of medium size, rather rapidly and gradually enlarging from below upwards, the diameter increasing to twice the size in the space of four and a half inches. Transverse section circular; length of the outer chamber not determined. Septa moderately concave, and closely arranged, but gradually increasing in distance with the increased size of the shell—six chambers occupying the space of one inch where the diameter of the shell is one and a half inches at the upper one of those measured; nearer the joint there are ten to twelve in the same distance where the diameter is only three-fourths of an inch. Siphuncle eccentric, situated a little nearer to the center than to the margin; very small where it passes through the septa, but expanding within the chambers to about four times its diameter at the other point, and forming a flattened bead-like body within each chamber.

"Surface of the shell apparently smooth, except that the edges of the septa are raised above the general level, in the form of narrow rings. This feature may possibly be due, in part at least, to an expansion of the septa during the process of petrifaction, but it would scarcely seem to be the case, as the feature is too regular, and only shows where the external shell is wholly or partly preserved. The rings are often some little wider on the surface than the thickness of the septa. Where the surface is most perfectly preserved there is also a finely reticulate or net-like character, dividing the surface into small rhombic figures of microscopic dimensions, having their longest diameters corresponding to the length of the shell, and presenting a surface similar to that frequently produced by the attachment of bryozoans; but the regularity is so great that this can not have been the origin of the feature; neither have the rhombs anything like a radial structure or direction in any part, as would have been the case if they were the result of the growth of a bryozoan. Along one side of the shell and directly opposite to the position of the siphuncle, there is a narrow, raised, longitudinal line, extending the entire length of the tube, but slightly interrupted just above each one of the annular rings.

"The species resembles somewhat the *O. crebriseptum,* Hall (Paleontology of New York, Vol. I, p. 313, pl. 87), but increases much more rapidly in size, and does not possess the longitudinal markings of that species. In the rapid expansion of the tube it corresponds nearly with *O. Sieboldi,* Bill., from the island of Anticosti; but the septa are much more numerous, that one having seventeen in the space of seven inches, while this one has the same number in the space of two and one half inches."—Hall and Whitfield, *loc. cit.*

The type is from the Richmond formation at Waynesville, Ohio. I have with great hesitation listed a specimen as this species, coming from a slightly lower horizon on Tanner's Creek, Indiana.

ORTHOCERAS GORBYI Miller.

Plate LII, fig. 3.

Orthoceras gorbyi Miller, 1893, Geol. Nat. Hist. Indiana, XVIII, p. 322, pl. x, fig. 2.

"Shell about medium size, among species from the Hudson River Group, very long, slowly and gradually enlarging from below upward, and increasing in diameter only .04 of an inch in an inch in length; transverse section subcircular; septa very moderately concave, closely arranged, thirteen of them occurring in a distance equal to the diameter of the shell, where the diameter is 1.1 inches; surface marked by broad furrows or undulations that cross the shell at an angle of twenty or twenty-three degrees from the ventral to the dorsal side. The two specimens examined are casts, but one of them bears a few fine longitudinal lines that indicate the surface of the shell was so marked; body chamber and siphuncle unknown.

"This species will be distinguished by its elongate form, close septa and inclined undulations.

"Found by A. C. Benedict, in the Hudson River Group, in Franklin County, Indiana, and now in his collection. The species is named in honor of the State Geologist."—Miller, *loc. cit.*

ORTHOCERAS JUNCEUM Hall.

Plate LI, figs. 5-5c.

Orthoceras junceum Hall, 1847, Pal. New York, I, p. 204, pl. xlvii, 3 a-f.

"Slender, terete-cylindrical, tapering very gradually; septa thin, distant from one fourth to one third the diameter; outer chamber deep; siphuncle small, central; section circular; surface finely striated transversely, but without longitudinal striae.

"This species presents a surface marked precisely similar to *Endoceras proteiforme,* var. *lineolatum*; but the shell is much more slender and gradually tapering, the siphuncle being always central. The septa, towards the outer chamber, are more closely arranged, sometimes two or three in the usual space of a single one.

"This is a constant species, presenting no important variation in its characters. All the specimens seen are imperfect, and the interior is often filled with crystalline matter, which obliterates the septa and siphuncle. The outer chamber, though incomplete, is proportionally very deep. Very little variation in size has been observed in all the specimens obtained."—Hall, *loc. cit.*

Reported in Kindle's list from Madison, Indiana. This is a Trenton species and very probably does not occur in Indiana. I have given figures and description, however, because Nickles in his list of Cincinnati fossils includes it among the species reported from the Utica formation. If he is correct, it may possibly be found in rocks of the same age in Indiana.

ORTHOCERAS MOHRI Miller.

Plate LI, fig. 3.

Orthoceras mohri Miller, 1875, Cincinnati Quarterly Journal of Science, II, p. 124, fig. 10.

"Shell elongated, tapering very regularly, at the rate of about 0.16 inch to the inch, to an acute point. Septa rather strongly arched, and distant about one fourth the diameter of the shell. (Measurement of three different polished specimens produced the following result: Diameter 0.62 inch, septa distant 0.15 inch; diameter 0.50 inch, septa distant 0.12 inch; diameter 0.25 inch, septa distant 0.06 inch.) Siphuncle central, and having the appearance of a connected series of oval beads, with the larger ends directed forward, and gradually diminishing in size, as the distance between the septa becomes less and less. Greatest diameter of the siphuncle about or a little more than one fourth the diameter of the shell. Outer chamber more than one fourth the length of the shell, measuring to the end of the siphuncle. Outer surface of the shell in good specimens smooth, and not showing the septa within.

"Polished specimens show septa commencing to form in the body chamber, in advance of the siphuncle; those near the siphuncle approaching, while those more distant only commencing to leave the outer shell.

"I found this species near Versailles, Ind., about 300 feet below the Upper Silurian rocks, associated with *Anodontopsis milleri, Anomalodonta gigantea, Modiolopsis Versaillesensis, Cyrtolites ornatus,* showing the outer shell and surface markings, and other fossils better preserved than I have found them elsewhere. The specific name is given in honor of our paleontological friend, Paul Mohr, Sr., Esq."—Miller, *loc. cit.*

Probably from somewhere in the Waynesville formation. There is not 300 ft. of Ordovician rock in the Versailles section.

OSTRACODA.

DIAGNOSES OF GENERA.

CERATOPSIS Ulrich.

Valves somewhat obliquely subovate, widest posteriorly, straight dorsally, with a thick rounded semicircular marginal ridge, and two submedian ridges extending obliquely upward from the marginal ridge, the anterior one reaching the dorsal edge, the other shorter and smaller; post-dorsal end of marginal ridge raised into strong spine-like or mushroom-shaped process, beaded or fimbriated along one edge or around the flattened top. Free edges of carapace as in *Ctenobolina,* being thick, and having 'false borders.' (Ulrich.)

CTENOBOLINA Ulrich.

Carapace small, elongate-suboval, strongly convex, the posterior two-fifths more or less decidedly bulbous or subglobular, and separated from the remainder by a deep, narrow and more or less oblique sulcus extending with a gentle curve from the dorsal margin more than half the distance across the valves toward the postero-ventral border. The anterior three-fifths often with another oblique but less impressed sulcus. Valves equal, the dorsal margin straight, hingement simple, the ventral edge thick, and the true contact margins generally concealed, in a lateral view, by a 'frill' or flattened false border; surface granulose, smooth, or punctate. (Ulrich.)

ENTOMIS Jones.

Shell subovate or fabiform; valves with a slightly curved submedian vertical furrow extending to hinge line; in front of furrow occasionally a rounded tubercle. Surface marked generally with raised, concentric, transverse or longitudinal lines. (Ulrich.)

EURYCHILINA Ulrich.

Carapace with a long, straight hinge line; semicircular, oblong-subquadrate, or somewhat rounded in outline; generally with a well defined subcentral vertical sulcus and a more or less prominent node immediately behind it. Except at the dorsal side, the valves are sourrounded by a wide marginal area, externally either flat or convex, and usually marked in a radial manner; on the inner side deeply concave, an outer wall being raised almost to the level of the true or closing edge of the valve; area terminated in most cases by a narrow rim-like border. Hinge simple. Surface beautifully reticulated, pitted, granulose or smooth. (Ulrich.)

LEPERDITIA Ronault.

Carapace more or less convex, often large, suboblong or semi-ovate in outline, with an oblique backward swing; dorsal edge straight, often angular at the extremities; ventral outline rounded, sometimes a little produced at the middle; greatest thickness in the ventral half, the lower edge usually being also blunt; valves unequal, the right the larger and overlapping the left; overlap chiefly ventral, simple, or the further entrance of the ventral edge of the left valve is prevented by two or more papillae set within the overlapping edge of the right; hinge simple. Surface frequently horny in appearance, smooth in most cases, granulose or minutely punctate in others; a small tubercle or "eye-spot" is generally present on the antero-dorsal fourth, and a large, rounded subcentrally situated sunken muscle-spot is seen on the inner side of the valves and not infrequently distinguishable on the exterior also. (Ulrich.)

PRIMITIA Jones and Holl.

Carapace small, varying in outline, usually subovate, but the hinge is always straight; valves equal, never overlapping, generally provided with a narrow border; in, or to one side of, the middle of the dorsal half, a well-marked pit or sulcus; the pit may be rounded or situated subcentrally, or it may be drawn out vertically so as to extend from the dorsal margin half across the valve; on one or both sides of the sulcus the surface may be raised into a low, rounded or ridge-shaped prominence. Surface of valves punctate, reticulate, or without ornament; in rare cases it seems to have been minutely granulose. (Ulrich.)

TETRADELLA Ulrich.

Carapace somewhat oblong, often subquadrate, never tumid, with the hinge line straight. Surface depressed, with a semi-circular ridge; within the enclosed space two simple or slightly modified, equal or unequal, and more or less nearly vertical ridges unite below with the marginal ridge and extend upward from it, one in many cases failing to reach the dorsal margin. Free edges usually with a simple flattened border; in one case (*T. subquadrata*) thick and with the contact margins concealed by a "false border." Surface smooth or granulose. (Ulrich.)

DESCRIPTION OF SPECIES.

BOLLIA PUMILA Ulrich.

Plate LIII, figs. 12, 12a.

Bollia pumila Ulrich, 1890, Jour. Cin. Soc. Nat. Hist., vol. XIII, p. 117, pl. xii, figs. 1a, 1b.

"Valves oblong-subelliptical, the anterior end somewhat narrower than the posterior, and with the point of greatest extension near the antero-dorsal angle; from here the edge curves backward into the uniformly convex ventral portion; posterior end rounded, nearly vertical, forming an obtuse angle where it joins the dorsal margin; the latter is never quite straight, but protrudes more or less in the central third of its length. A narrow ridge runs nearly parallel with the free edges, the abruptness with which it rises above them varying slightly. The ends of the inner or horse-shoe shaped ridge characterizing the genus are bulbous and project a little beyond the dorsal margin; the curved portion thin, generally a little oblique, and well separated from the marginal ridge.

"Size: Length, 0.86 mm.; height, 0.52 mm.

"This species is smaller than usual in this genus. Its chief peculiarity is the bulbous enlargement of the ends of the horse-shoe ridge. It is too clearly distinct from *B. persulcata,* Ulr., to require comparisons."—Ulrich, *loc. cit.*

The types are from the Richmond formation at Weisburg, Indiana. It is also known from other localities in Ohio and Indiana.

CERATOPSIS CHAMBERSI (Miller).

Plate LIII, figs. 1, 1a.

Beyrichia chambersi Miller, 1874, Cin. Quar. Jour. Sci., vol. I, p. 234, fig. 27.

"Shell small, subreniform, dorsal margin straight, nearly as long as the entire length of the shell, basal margin subelliptical; anterior end wider than the posterior. The body of the valve is crossed by two broad, deep sulci, one of which is situated immediately behind the eye tubercle in the anterior third, the other in the middle third of the shell. The projecting basal margin is marked with a depression throughout its length, and bordered with a carinated edge.

"The eye tubercle is about as long as the breadth of the shell, and rises like a half cone from the extreme anterior end, with the flattened face in the rear marked by fine oblique lines, very much resembling in appearance, when magnified, the teeth of a comb.

"Greatest length of the shell about 1/15 inch; breadth, one-third less.

"This species is readily distinguished from all others by the remarkable eye tubercle. In other respects it most nearly resembles *B. oculifer* (Hall), though not exactly corresponding with it.

"I first found it in the excavation for Columbia Avenue, in Cincinnati, about 150 feet above low water mark; subsequently I found it at Richmond, Indiana, in the upper part of the Cincinnati group, thus indicating that its range is coextensive with the exposure of the blue limestone. I found, however, only one slab at Richmond and two at Columbia avenue bearing the fossil, and do not know of any others having been found, but, considering its great range, we must expect to find it in some locality in great abundance, and the only reason this has not thus far been accomplished is most likely owing to the extreme minuteness of the fossil.

"The specific name is given in honor of our most eminent naturalist and learned entomologist, V. T. Chambers, Esq., of Covington, Ky."—Miller, *loc. cit.*

Miller, above, reports this species from the Richmond formation at Richmond, Indiana. From the statements of Ulrich, however, there would seem to be some doubt about the typical form of the species occurring in the upper part of the Cincinnati series. Apparently he would refer the Richmond forms to his variety *robusta.*

CERATOPSIS CHAMBERSI var. ROBUSTA Ulrich.

Plate LIII, figs. 2, 2a.

Ceratopsis chambersi var. *robusta* Ulrich, 1894, Geological and Natural History Survey of Minnesota, vol. III, pt. II, p. 677, fig. 50.

"This designation is proposed for the variety which occurs in the upper beds of the Cincinnati group at numerous localities in Ohio, Indiana and Kentucky, and in the equivalent Hudson River group strata of Minnesota. So far as known it is not to be found below the horizon of *Orthis subquadrata* Hall, and *Rhynchotreta capax* Conrad. It differs from the typical form of the species in having all the ridges somewhat thicker, and the post-median one much larger. In many cases the latter is nearly or quite equal to the anterior ridge, and extends like it entirely across the valve. The ventral portion of the carapace also is thicker, and the marginal ridge subangular where the contour turns abruptly inward to the false border."—Ulrich, *loc. cit.*

Reported by Ulrich from Richmond and Versailles, Indiana. Liberty (?).

CERATOPSIS OCULIFERA Hall.

Plate LIII, figs. 3, 3a.

Beyrichia oculifer Hall, 1871, 24th Report of the New York State Museum, p. 232, pl. viii, figs. 9, 10.

"Carapace small, seldom exceeding seven-hundredths of an inch in length, by three to four-hundredths in the greatest breadth in the largest specimens; valves obliquely subreniform, broadest near the anterior end, with a straight hinge line, which is a little shorter than the greatest length of the valve; anterior end projecting beyond the hinge; center moderately convex, with a proportionally broad, deep channel just within the margin, extending all around it, except for a short distance at the posterior extremity near the dorsal margin. The body of the valve is crossed obliquely by two deep furrows, having their origin on the dorsal margin, the posterior one situated a little more than one-third of the length of the valve from the posterior extremity and extending fully two-thirds across it; the anterior furrow is situated just behind the anterior third of the length, and in its lower portion is more strongly curved forward than the other. Eye tubercle large, pedunculated, very prominent, and spreading at the top, its surface equal to about one-third the width of the valve, and its height at the posterior margin equal to the breadth of the top, while the anterior margin is but little elevated, giving an obliquely sloping circular surface, with a denticulated border. This surface, under a strong magnifier, is seen to be covered by fine eye-like facets, similar to those of the eyes of Triliobites of the genus ILLAENUS.

"This species is very distinct from any other described, in the form and strength of the transverse furrows, and especially in the great prominence of the club-shaped eye tubercle. So far as can be ascertained, it is the first species of this group of crustaceans in which the eye facets have been detected."—Hall, *loc. cit.*

1.34C10.

CTENOBOLINA CILIATA var. HAMMELI (Miller and Faber).

Plate LIII, fig. 6.

Beyrichia hammeli Miller and Faber, 1894, Jour. Cin. Soc. Nat. Hist., XVII, p. 157, pl. viii, fig. 26.

"Carapace medium size, dorsal margin straight and nearly as long as the greatest length of the valves. Anterior and posterior extremities broadly rounded, the anterior being slightly the wider of the two. Greatest width of the valves at the anterior third, where the width is to the length of the dorsal margin about as three is to four. Basal margin rounded, and slightly advancing at the anterior third. Valves moderately convex, with a border on the anterior, posterior, and basal margins, separated from the valve by a sharply-defined line or groove. The border on the basal margin is about one-sixth the width of the valve, and it narrows to about two-thirds that width at the antero-dorsal angle, and to about one-third that width at the postero-dorsal angle. The body of the valve is constricted by two sulci, directed obliquely backward from the basal border of the shell; the anterior one arises at the groove separating the border from the body of the shell, at the antero-basal margin, and when half way across the valve bifurcates, the stronger sulcus directed forward toward the antero dorsal margin, and the shallower one fading out before it reaches the dorsal margin of the shell. There is thus formed, anterior to this sulcus, a large, convex, rounded area, and between the branches of this sulcus and the dorsal margin a depressed, convex, subtriangular area. Between the two oblique sulci there is a convex ridge more prominent than the rounded area in front, and which extends farther toward the basal margin than either the anterior or posterior convex areas. The posterior oblique sulcus fades out before it reaches the dorsal margin. The area between the posterior oblique sulcus and the posterior extremity of the valve is wider, but not as prominent as the more central ridge between the oblique sulci.

"The surface of the valves is distinctly granulous. The margin of the border, as seen from the interior side of the shell, is fringed or ciliated in the same manner as *Beyrichia ciliata*.

"This species, when compared with *Berychia ciliata,* is proportionally wider; has a wide border, while that species has only a linear border; has deeper sulci and a more convex ridge between them. Judging from some recent publications on the Ostracoda, there are those who would affix a new generic name to this species, but what light that would shed upon its characters, or how it would advance knowledge or assist in classification, we are unable to understand. We think it is a true *Beyrichia.*

"Found in the upper part of the Hudson River Group, by one of the authors, at Versailles, Indiana, associated with *Cyclora pulcella, Palaeoconcha faberi, Hyolithes versaillesensis,* and other small fossils.

"The specific name is in honor of Mr. J. F. Hammel, the well-known geologist of Madison, Indiana."—Miller and Faber, *loc. cit.*

ENTOMIS MADISONENSIS Ulrich.

Plate LIII, figs. 8, 8b.

Entomis madisonensis Ulrich, 1890, Jour. Cin. Soc. Nat. Hist., vol. XIII, p. 107, pl. vii, figs. 12a, 12b.

"Valves oblong-ovate, the back straight but short, the ends subequal and curved almost uniformly into the much more gently convex ventral edge. Sulcus deep, nearly central, extending from the dorsal edge fully two-thirds across the valve, bending forward a little at its lower extremity. Anterior half moderately convex; posterior half more so, and rising abruptly from the sulcus. Surface smooth.

"Size: Length, 1.3 mm.; height, 0.78 mm.

"This, and a much larger form from the Niagara of Indiana, are the only species of *Entomis* at present known to me from American rocks. Though apparently a true species of the genus, *E. madisonensis* does not seem to be very closely related to any of the European forms.

"The strong sulcus will distinguish it from species of *Primitia.*"—Ulrich, *loc. cit.*

The types are from the uppermost beds of the Cincinnati series at Madison, Indiana, where it is said to be rare.

EURYCHILINA STRIATOMARGINATA Miller.

Plate LIII, fig. 9.

Beyrichia striato-marginata Miller, Cin. Quarterly Jour. of Science, I, p. 233, fig. 26.

"Shell small, semi-elliptical; dorsal margin straight, rounded at both ends; basal margin elliptical. Valves strongly convex, with a single depression extending from the middle of the dorsal margin, at right angles, about half the breadth of the shell. Border one third the width of the shell, and finely striated or lined from the shell outward.

"Length about 4/60th inch, and width about 2/60th inch; convexity nearly as great as the width.

"I found this species in the upper fifty feet of the Cincinnati group, about fifty miles west of Cincinnati and about three miles south of Osgood, Indiana."—Miller, *loc. cit.*

Saluda.

LEPERDITIA CAECIGENA Miller.

Plate LIII, figs. 10-10c.

Leperditia caecigena Miller, 1881, Jour. Cin. Soc. Nat. Hist., vol. IV, p. 262, pl. vi, figs. 5, 5a.

"Length usually about 12/100 inch, breadth about 8/100 inch, and thickness about 4/100 inch.

"General form subovate. Hinge line straight, a little more than half the length of the valves. Anterior end narrower than the posterior, extending but little beyond the hinge line, when it rapidly curves into the ventral line below. The posterior part is broadly rounded, and constitutes beyond the hinge-line full one-third the length of the valves. Valves most convex at the posterior third. Surface smooth and eye-tubercle obsolete.

"This is a true Leperditia, as one valve overlaps the other.

"The author collected this species in the upper part of the Hudson River group at Versailles, and near Osgood, Indiana. The specimens illustrated and described are in his collection."—Miller, *loc. cit.*

Reported by Ulrich from near Madison, Indiana.

PRIMITIA CINCINNATIENSIS (Miller).

Plate LIII, figs. 11-11d.

Beyrichia cincinnatiensis Miller, 1875, Cincinnati Quarterly Journal of Science, II, p. 350, fig. 25.

"This is the smallest *Beyrichia,* known to me, in the Cincinnati rocks. It belongs to the unisulcate group of 'simplices,' and is very closely related to the *Leperditia.* General form elliptical, with a straight dorsal edge. Surface of the valves smooth, convex, with a single depression extending from the middle of the dorsal margin across about or a little over half the breadth of each valve. Ventral and terminal margins bordered by a very narrow depressed rim.

"Length of specimen about 2/100 inch; breadth about two thirds the length.

"It is found associated with *B. quadrilirata,* on slabs, about three miles east of Weisburg on the I. & C. R. R., and with the same fossil and *B. chambersi* about two miles north-east of Fort Ancient, on the L. M. R. R. The rocks at each of these places are about 300 feet below the upper Silurian."—Miller, *loc. cit.*

Arnheim.

PRIMITIA IMPRESSA Ulrich.

Plate LIII, figs. 7-7d.

Primitia impressa Ulrich, 1890, Jour. Cin. Soc. Nat. Hist., vol. XIII, p. 131, pl. x, figs. 3 a-c, 4 a-c.

"A small, ovate species, rather tumid, with the dorsal and ventral margins nearly equally convex, and the ends equal, or the anterior slightly the widest. The free margins usually with an indistinct flange. Sulcus situated centrally, or a little in front of the middle, unusually deep, extending from the dorsal edge nearly half the distance across the valve, terminating abruptly. Just behind the sulcus a more or less faint swelling.

"Size: Length, 0.6 mm.; height, 0.36 mm.

"The valves of this species are more convex than those of *P. fabulina*, Jones and Holl, and *P. humilis*, Jones and Holl, to both of which it is closely related. Both of those species differ further in having the posterior end wider, and the point of greatest convexity further removed from the dorsal edge. There is no species known to me from American rocks resembling this sufficiently to make comparison necessary."—Ulrich, *loc. cit.*

1.34A1, 3, 4, 7, 8 (?).

TETRADELLA QUADRILIRATA Hall and Whitfield.

Plate LIII, figs. 4, 4a.

Beyrichia quadrilirata Hall and Whitfield, 1875, Pal. Ohio, II, p. 105, pl. iv, figs. 6, 7.

"Carapace minute, the larger individuals seldom exceeding three-hundredths of an inch in length, and often not more than that size. Form sub-quadrangular, longer than wide, the proportions being about as two to three, and a little the widest at the anterior third of the length. Dorsal margin straight, a little less than the length of the valve; ends squarely rounded, and the basal line scarcely flattened. General surface of the valves flattened, but marked by transverse furrows, four in number, three of which are distinct and deep, extending across, or nearly across, the valve; the fourth is less distinctly marked and extends but little more than half way across the valve. The furrows divide the surface of the valves into transverse ridges, which are situated, one at each end, and one at each third of the length. Those situated at the ends are narrow and abruptly elevated; that at the anterior third of the length does not reach quite to the dorsal margin; while that of the posterior third is much the strongest, rapidly widens in the lower part, and divided along the middle by the fourth, or smaller furrow, which gives it the character of a strong ridge, bifurcating in the lower half. The central furrow is wider than the others, oblique in its direction, and somewhat curved in its course toward the ventral border. The margin of the valves is strongly and abruptly depressed below the general surface, forming a narrow, flange-like projection around the ends and basal portions. Surface of the crust not spinose or granulose under a lens of moderate power.

"The species somewhat resembles *B. trisulcata,* Hall, from the Lower Helderberg group, in the general expression of the valves, but differs in the relative position of the furrows. The specimens vary considerably in the strength of the ridges, these, in some cases, being broad and rounded, as in the specimen figured, while in others they are sharp and narrow, leaving broader furrows between."—Hall and Whitfield, *loc. cit.*

The types are from the Richmond formation near Waynesville, Ohio. The species is also reported by Ulrich from Richmond and Versailles, Indiana, from the Richmond formation.

TETRADELLA QUADRILIRATA var. SIMPLEX Ulrich.

Plate LIII, figs. 5, 5a.

Strepula quadrilirata var. *simplex* Ulrich, 1889, Contributions to the Micro-Paleontology of the Cambro-Silurian rocks of Canada, II, p. 55, pl. ix, fig. 13.

"Figure 13, plate IX [of Ulrich's paper] represents a variety from Stony Mountain, Manitoba, that may be designated as var. *simplex.* It differs from the typical form in having the postero-median ridge simple instead of bifurcated below. The vertical plates which divide the anterior edge of the typical form into shallow cavities seem also not to have been developed except to a very limited extent. A very similar variety occurs in the Trenton shales of Minnesota."—Ulrich, *loc. cit.*

Reported by Ulrich from Weisburg, Indiana, from the Richmond formation.

CIRRIPEDIA.

LEPIDOCOLEUS JAMESI (Hall and Whitfield).

Plate LIII, figs. 13-13d.

Plumulites jamesi Hall and Whitfield, 1875, Pal. Ohio, p. 106, pl. iv, figs. 1-3.

"General form of the plates triangular, with the apex a little inclined to one side, the lateral margins gradually and rapidly diverging from the initial point, one of them considerably longer than the other. Basal margin sigmoidal, the convex portion situated next to the longest lateral face, the concave portion to the shorter, and the shorter lateral margin deflected downwards in some cases (probably the marginal row of plates).

"The surface of the plates is flattened or slightly convex on the sides, and very faintly depressed along the middle, the whole marked by rather closely arranged, annulating, and scaliform transverse lines parallel with the basal or sigmoidal margin, and marking stages of growth. These transverse lines are usually faintest near the apex, and gradually increase in width with the increased growth of the plate, but in some cases they are quite irregular in their distances.

"The length from the apex to the basal margin of the plate is usually a little greater than the transverse diameter, and seldom exceeds a sixteenth of an inch, the largest specimens seen not measuring a line in their greatest diameter."—Hall and Whitfield, *loc. cit.*

I have seen many fragments of a species probably the same as the above, though I do not feel that the identification is a sure one.

5.9A8....1.34A3, 4, 7, 8, 10, 12, 15a....1.34C8.

TRILOBITA.

DIAGNOSES OF GENERA.

ACIDASPIS Murchison.

Cephalon semicircular or semielliptical, thickened margin spinous and genal angles produced into spines of greater or less length. Glabella with one large median lobe and two on either side, one or more spines frequently project backward from the posterior margin of the glabella. Eyes prominent. Thorax with eight or nine segments; pleurae laterally extended into long spines, ridged. Pygidium small, margined with spines.

CALYMMENE Brogniart.

Body oval in outline, possessing the power of enrolement to perfection; glabella conical, strongly convex, divided by three pairs of deep lateral grooves; eyes small; hypostoma quadrate, notched. Thorax of thirteen segments, axial furrows deep; pygidium of from six to eleven segments, not distinctly marked off from the thorax. (Beecher.)

CERAURUS Green.

Body very much depressed and slightly tapering. Cephalon scarcely trilobate; cheeks large, flat, with small remote oculiform tubercles; posterior (genal) angle of the cephalon spinous. Thorax with twelve articulations. Pygidium rounded at the end, but terminating on each side with two slightly curved spines. (Green.)

DALMANITES Emmrich.

Glabella with three well-marked lateral furrows; genal angles produced into spines; eyes large, prominent, and with many distinct facets; pygidium triangular, frequently pointed or mucronated, with more than eleven segments, sometimes twenty or more. (Beecher.)

ASAPHUS Brogniart.

Cephalic and caudal shields of nearly equal size, with broad infolded margin; glabella expanded, nearly smooth; free cheeks large; hypostoma deeply forked; eyes large and prominent; thoracic segments eight; pygidium not strongly segmented, often nearly smooth. (Beecher.)

Subgenus ISOTELUS DeKay.

Same as in *Asaphus*, but with broad unsegmented pygidial axis at maturity.

PROETUS Steininger.

Head-shield semicircular, with thickened marginal rim; glabella well defined, extending nearly to the anterior margin, lateral furrows obsolescent, basal lobes often present. Eyes large, crescentic, near the glabella; thoracic segments usually ten, pleura grooved; pygidium semicircular, margin entire, axis elevated, segmented; limb ribbed. (Beecher.)

TRINUCLEUS Lhwyd.

Cephalon with a broad, regularly pitted border, produced behind into long genal spines; glabella prominent; thorax of six segments; axis narrow; pygidium triangular, wide, short. (Beecher.)

DESCRIPTION OF SPECIES.

ACIDASPIS CERALEPTA (Anthony).

Plate LIV, figs. 1, 1a.

Ceratocephalia ceralepta Anthony, 1838, Amer. Jour. Sci., XXXIV, p. 379, figs. 1, 2.

"*Ceratocephala ceralepta.*—Clypeo antice rotundato, subplano, granulato.

"Margine crenulata.

"Cornibus prorsum expansibus et gracilibus.

"The buckler is semi-lunate, surface covered with fine granulations resembling shagreen; its margin is raised, presenting a rounded rim, over which pass two antennae, distant from each other where they pass over about one fourth of an inch. These antennae extend one third of an inch beyond the rim, and are only one third of a line in diameter, forming a character from which we derive our specific name, 'ceralepta' (slender horned); their extremities are broken off, and it would appear that they have been several lines longer; they diverge a little at their extremity, being about one line more distant there than at the margin of the buckler; they are inserted about one line within the rim. Between the horns there is a triangular process extending from the rim back as far as their insertion; this has two deep sulci on each side, separating it from the antennae. No abdomen or tail has yet been found, which could be identified as belonging to this species.

"Only two specimens are known to have been found, both by myself. They were discovered among the rubbish thrown down from a quarry, half a mile from this place [Cincinnati]. Millions of fragments may be found there of Calymenes, Isoteli, etc., and we may hope a more perfect specimen of our own species.

"When first shown to some scientific friends, it was pronounced a part of Ceraurus pleurexanthemus, and Dr. J. Green so judged it from an imperfect cast shown him. Those who have since had an opportunity of comparing my specimen with a Ceraurus Pleurexanthemus found in this vicinity this spring, have discovered that it cannot be confounded with it. Among those who thus doubted at first, and afterwards became convinced, I may mention Dr. J. A. Warder of this place, who, on a recent visit to Springfield, Ohio, found among some fossils belonging to his sister a specimen of what he deems another species belonging to the same genus with the present. On consultation, we have concluded to form a new genus, to be called Ceratocephala (*horned head*)."—Anthony, *loc. cit.*

The figures given herewith (after Meek) are of two fragments similar to those from which the above original description was drawn up. Anthony's description applies to the pygdium which he mistook for the cephalon of his species, as pointed out by Meek, the "antennae" being the two pygidial spines.

I have referred fragments from the Utica formation at Vevay (1.38 A 24 and 29) to this species.

ACIDASPIS CINCINNATIENSIS Meek.

Plate LIV, fig. 2, 4(?).

Acidaspis cincinnatiensis Meek, 1873, Pal. Ohio, I, p. 167, pl. xiv, fig. 3.

"Cephalic shield, and most of the thorax unknown. Pygidium, exclusive of its spines, about three times as wide as long, and approaching a sub-semicircular outline; its anterior margin being straight all the way across, and about one-third of its posterior margin in the middle transversely truncated, while on each side of this the posterior lateral margins are straight to the anterior lateral angles; mesial lobe prominent at the anterior end, where it is about as wide as each lateral lobe, but becoming rapidly depressed and narrowed posteriorly, composed of only two well defined segments; lateral lobes flat, excepting a ridge that extends obliquely backward and outward from the anterior segment of the mesial lobe, across each, to the posterior lateral margins, where these ridges terminate in prominent, rounded, diverging spines; while the posterior lateral margins between these spines and the lateral angles are each armed with four smaller slender spines directed obliquely backward and outward; four similar smaller spines also occupy the truncated middle part of the posterior margin between the larger ones. Surface smooth, excepting a few very minute scattering asperities on the spines.

"Of the thoracic segments, the posterior one, and a part of the next one in advance of it, are seen in connection with the pygidium in the matrix. These show that the posterior extremity of the mesial lobe of the thorax is about as wide as the lateral lobes, moderately arched upward (not forward), and nearly or quite smooth, while the lateral lobes are flat. The pleurae of the posterior thoracic segment are smooth, and have each a strong mesial ridge extending straight outward to the lateral extremity, where it curves abruptly backward, and is produced into a long, sharp spine, extending as far backward as the longest spines of the pygidium, or farther. The anterior margin of each of these pleurae has also the character of a more slender, depressed marginal ridge, that likewise terminates in a backward curve, but much smaller lateral spine, just in front of the larger one, while there is behind the larger mesial ridge a narrower, flat margin, that runs out to nothing before reaching the outer extremity.

"Length of pygidium, exclusive of spines, 0.19 inch; breadth of do., 0.55 inch. Transverse diameter of first thoracic segment in advance of pygidium, 0.70 inch; length of each pleurae, 0.23 inch; anterior-posterior diameter of the same, 0.08 inch; length of larger lateral spine of each, 0.38 inch.

"That this species is distinct from the form I have referred to Dr. Locke's *A. crosotus,* seems to be evident, not only from its much larger size, but because it shows no traces of the rather distinct, closely set granulations seen on all parts of that species, and differs in other details. In many respects it appears to be closely related to *A. prevosti* of Barrande, so far as we have the means of comparison; but still it wants the distinct surface granulations of that form, and hence would doubtless be found to present other differences, if we had the entire fossil to compare.

"I have also before me a right, movable cheek of an *Acidaspis* from Cincinnati, that may, judging from its size and general appearance, belong to this species. Its posterior extremity is produced in the form of a long, stout, rounded spine, covered with little asperities, while the margin of this cheek is armed by about twelve short digitations. The inner or under side of this specimen is represented by our figure 4, of plate 14 [of Meek's paper]. Fig. 5 of the same plate represents the inner side of another similar cheek, with a more slender terminal spine, longer digitations, and a greater breadth between the eye and the digitate margin, from a higher position in this series, at Dayton, Ohio.

"Mr. James's collection also contains two specimens of the glabella of one or two species of *Acidaspis,* with a long spine projecting backward from the occipital portion. They differ enough in details to belong to two distinct species, and yet may belong to varieties of the same form. Of course, without other specimens showing these parts in connection, it is not possible to determine what relations they may bear to the pygidium for which I have proposed the name *A. cincinnatiensis.* I suspect, however, that one or the other, or both, belong to that species, and yet they may be quite distinct from it. It was evidently to one of these forms that Dr. Locke referred, in Vol. XLV, p. 223, of the Am. Jour. Sci. and Arts, published in 1843, as possibly belonging to his *A. crosotus.* They are certainly distinct from that form, however, not only in their much larger size, and the possession of the long appendage to the back part of the head, but in the form and comparative sizes of the lateral lobes of the glabella. They seem to be related to *A. grayi* of Barrande, though differing in details.

"If these specimens should be found to belong to a distinct species from any of those yet named, I would propose for it the name *Acidaspis rhynchocephalus,* in allusion to the beak-like appendage of the back of the head."—Meek, *loc. cit.*

I have seen only a few small fragments that may belong to this species.

1.12E3.

ACIDASPIS CROSOTUS (Locke).

Plate LIV, figs. 5, 5a.

Ceraurus crosotus Locke, 1842, Amer. Jour. Sci., XLIV, p. 346, wood-cut.

"*Messrs. Silliman*—I enclose to you a drawing of a new species of trilobite, evidently of the genus Ceraurus of Green. It is one of the smallest, and at the same time one of the most elegant of this family of extinct crustaceans; this drawing being magnified three times in linear dimensions. Fragments of this species have been repeatedly found in the rocks of this vicinity, especially the fringed margin of the shield; but it was not until last summer that I procured a specimen so nearly entire as to determine its generic relations. When Dr. Green established the genus of Ceraurus, it consisted of only one species, the *Pleurexanthemus.* But now that other species very closely allied to that are found, the justice of his discrimination is very apparent. I have named this new species *crosotus,* from the Greek word, signifying fringed. Dr. Green's description of his species—'Clypeo, postice arcuato, angulo externo in mucronem valde producto, occulis minimis remotis, post abdomine in spinam arcuatam utrinque extenso'—applies quite well to the *crosotus*; but this last differs from the former in having the shield pectinate or fringed anteriorly. The spines of the shield and of the several ribs are more nearly straight. Besides the spines terminating the ribs, there are six slender teeth, similar to those of the anterior fringe, attached, not to ribs, but to the terminal margin of the tail, four of them between the two last costal spines, at *a,* and the other two outside or anterior to the same, at *b.* Each of the costal arches is marked by *two* tubercles or 'pimples' (one in the other species), one on its middle, and the other at the commencement of the free spine in which each costal arch terminates. These tubercles form four rows or lines down the body, two on each lateral lobe, the inner one being in the direction of the distant eyes.''—Locke, *loc. cit.*

As I have seen only small fragments referable to this species I have reproduced the figure given by Meek in the Ohio Paleontology. From Meek's description I condense the following additional points:

Subovate or sub-elliptic in outline. Cephalon semicircular in outline, lateral angles produced into slender, sharp, somewhat curved spines that extend outward and backward to about opposite the fifth or sixth segment. Glabella with an oblong, subelliptic outline, the widest part being somewhat behind the middle and behind the eyes. Two lateral lobes on each side, of slightly oval outline, with their long diameters directed a little obliquely outward and forward; the posterior slightly larger than the anterior, and both separated from the middle lobe of the glabella by well defined furrows. Anterior lobe about as large as all four of the lateral lobes, twice as wide as the narrow part of the glabella and apparently rounded in front. Between the lateral lobe and each eye is a sort of outer or supplementary lobe as large as each two of the lateral lobes, and from the outer side of each of these protrudes the small prominent palpebral lobe. Eyes unknown, but apparently small. Neck segment large, prominent, with a central tubercle, and well defined by the neck furrow, which arches forward in the middle. Thorax nearly twice as long as the cephalic shield, and about one-fourth wider than long, exclusive of the produced extremities of the pleurae, segments slightly arching upward, but not forward. Lateral lobes comparatively rather depressed and rounding off gradually toward the lateral margins. Pleurae terminating in sharp spines directed outward and more or less backward, the posterior ones being longer and directed more backward. Pygidium small, and with its mesial lobe composed of about three or four segments; lateral lobes consisting apparently of about four segments, each of which terminates in an acute spine, the lateral ones of which are larger than the others, and curved backward. Entire surface rather coarsely granular, the granules being larger on the head than elsewhere; while on each pleura a large granule occurs at a point about half way out to the knee, at which point there is also some appearance of another granule.

I have referred to this species fragments from near Guilford. 1.34C6.

CALYMENE CALLICEPHALA Green.

Plate LIV, figs. 6-6c.

Calymene callicephala Green, 1832, Monograph of the Trilobites of North America, p. 30, cast No. 2.

"Clypeo antice attenuato, figura liliiformi in fronte depicta; oculis minimis; abdomine quatuordecim articulis; corpore plano.

"The buckler is subtriangular; on the front there is a figure in high relief, somewhat resembling a *fleur de lis,* or, perhaps more, the capital of a Corinthian column. The oculiferous tubercles are rather lower down on the cheeks than usual. The articulations of the abdomen and the tail cannot well be distinguished from each other; fourteen in all may be easily counted. The middle lobe of the abdomen is nearly equal in breadth throughout. The ribs, or costal arches, are not grooved or bifurcated at their extremities. Length nearly two inches and a half.

"This beautiful species is in the Philadelphia Museum, where it is labeled as being found in 'Hampshire, Virginia.' It is mineralized by a dark yellowish limestone. It differs from C. Blumenbachii in the form and number of its articulations; in the shape of the head; in having only two flat tuberculous elevations on the front; and in other particulars.

"In the cabinet of the New York Lyceum, and in that of J. P. Wetherill, Esq., there are some examples of this species from the Miami river, near Cincinnati, Ohio. I have also seen it from Indiana, in a dark coloured limestone, very much distorted. It has never been found at Trenton Falls, or at any other locality, as far as my knowledge extends, which yields the true C. Blumenbachii." —Green, *loc. cit.*

The illustrations given herewith will make the identification of this common and characteristic species easy, without further description. It is perhaps the most sought after by amateur collectors of any fossil in the Cincinnati series, and in the more accessable localities perfect specimens are becoming increasingly rare. Its range is coextensive with the Cincinnati series, though it is abundant at comparatively few levels.

5.9A2....1.34A1, 3, 7, 8, 10, 11, 13b, 14a, 14b, 15a, 15b, 16b, 17, 19-21, 22....1.34B4-5....1.34C5, 6, 7, 10, 11, 13, 14a.... 1.41B1, 3....1.41C1, 2-3....1.41D1, 2....1.41E4....1.12A2.... 1.12D1-6....1.12E3.

CERAURUS PLEUREXANTHEMUS Green.

Plate LIV, figs. 9-9b.

Ceraurus pleurexanthemus Green, 1832, Monograph of the Trilobites of North America, p. 84, cast No. 33, fig. 10.

"Clypeo postice arcuato, angulo externo in mucronem valde producto; oculis minimis remotis, post-abdomine in spinam arcuatam acutam utrinque extenso.

"The exact contour of this species cannot be perfectly ascertained from our specimens; it seems, however, to have been lunate. The horns of the crescent which form the posterior angles are very distinct, and they project like curved spines, some distance on each side of the head. The middle lobe or front is faintly scalloped on each side along the cheeks. The cheeks are rather large, and are furnished with two small oculiform tubercles, very remote from each other, and quite near to the anterior portion of the buckler. The abdomen is composed of twelve articulations. The lateral lobes of the abdomen are flat, and each of the ribs, at about half their extent, is marked on the upper surface, with an elevated pimple. These little pustules are nearly on a line with the oculiferous tubercles of the buckler, and present two parallel ranges down the body, one on each side of the middle lobe, and are terminated by a curved spine, which projects to some distance beyond the tail of the animal. Length, one inch and a fourth.

"This remarkable organic relic was found near Newport, in the State of New York. It is embedded in black limestone shale, and so exceedingly depressed is this animal that a very thin lamen of the slate removed from the surface would destroy every vestige of its appearance. I am indebted to my early friend, Professor T. R. Beck, for the use of this valuable petrifaction, which now belongs to the cabinet of the Albany Institute."—Green, *loc. cit.*

Of this species I have seen only an imperfect, but unmistakable, pygidium from the base of the Lorraine at Manchester, Indiana, and another fragment from the base of the Waynesville formation near Harmon's Station, Indiana. For the identification of the first I am indebted to the late Dr. C. E. Beecher, to whose opinion on such points only the highest regard can be paid. So far as I am aware, the species has not heretofore been reported from this horizon of the Cincinnati region. 1.34 C 13 and 1.34 A 3.

CERAURUS ICARUS (Billings).

Plate LIV, figs. 8, 8a.

Cheirurus icarus Billings, 1859, Canadian Naturalist and Geologist, vol. V, p. 67. (Also Geol. Canada, Report of Progress—1863—page 219, fig. 231.)

DALMANITES BREVICEPS Hall.

Plate LIV, figs. 10, 10a.

Dalmania breviceps Hall, 1866, 24th Report of the New York State Museum, p. 223, pl. viii, figs. 15, 16. (Published in 1866, republished in 1872.)

"Body broadly ovate in general form, having its greatest width across the base of the cephalic shield. Head subcrescentiform, the anterior margin very slightly produced in front of the glabella. Frontal lobe of glabella transversely elliptical, the breadth nearly twice as great as the length, separated from the anterior lobe by deep narrow furrows. Anterior lobe transversely subovate, prominent; middle and posterior lobes obsolete; occipital ring narrow, distinctly defined.

"Eyes very prominent, with five lenses in the central vertical range, but the number of vertical ranges cannot be determined; palpebral lobe depressed. The outer border of the movable cheeks is thickened and rounded, and the space between the border and the eye depressed. The posterior spines long and broad, reaching to the sixth thoracic segment.

"Thorax with the axial lobe highly convex and the lateral lobes strongly geniculate, subequal in width, rapidly tapering posteriorly from the fourth or fifth segment. Segments curved forward on the top of the axial lobe, and the furrows on the pleura strongly marked.

"Pygidium obtusely pointed behind, the lateral borders inclosing an angle of about 120°, the anterior border rounded; the number of articulations not clearly defined, but apparently numbering about ten or twelve, besides the terminal one; those of the lateral lobes have been more numerous.

"The entire surface, so far as can be seen on the specimen, has been finely pustulose.

"This species differs from all others described, in the short cephalic shield, and in the absence of middle and posterior glabellar lobes. In general form, it resembles *Dalmania callicephalia* of the Trenton limestone of New York; but differs conspicuously in having spines on the posterior angles of the cephalic shield."—Hall, *loc. cit.*

Doubtfully reported from Madison, Indiana.

ISOTELUS MAXIMUS Locke.

Plate LV, fig. 1. (*Isotelus gigas.*)

Isotelus maximus Locke, 1838, 2d Annual Report of the Geol. Surv. Ohio, p. 247, figs. 8, 9.

The description given by Locke in 1838 of this species is of so untechnical a sort as to be of very little value, were it not for the figures with which he accompanies it. I extract from his remarks whatever can be said to have any special bearing upon the diagnostic characters of the species in question.

Locke's specimen has a "kind of shovel shaped termination at both ends * * * large eyes, placed on the highest part of his body, * * * The animals were of various sizes, from less than an inch in length to 21 inches * * * [the specimen] is a fragment of the under margin of the tail or post abdomen of the animal, and when viewed sideways, exhibits a convex and a concave part precisely like the 'moulding' called the 'O-gee' * * * I am not sure that my specimen is not actually an overgrown megalops of Green; the character 'cauda suborbiculari limbo lato,' applies exactly, and the only definable difference which I can perceive between Dr. Green's specimen and my own is that the length of the post abdomen in his specimen is two thirds of its width, while in mine *it is less than two thirds.* The size, which is hardly a character, is very different, his being 5 inches, and mine 21 in length. I merely propose it as a new species, under the name of maximus, leaving it for those who have the means of more extensive comparisons than I possess to determine the question."—Locke, *loc. cit.*

Clarke has pointed out in the Paleontology of Minnesota that the sole distinction between this species and the *Isotelus gigas* is in the presence of genal spines in *I. maximus* and the absence of these structures in *I. gigas.* The spinous individuals are also in the New York and Minnesota specimens always smaller. Locke has indicated spines in the sketch which he gives of his extraordinarily large specimen. In general, my observation indicates that even very large individuals in the Cincinnati region possessed the genal spines. I have not seen any perfect specimens of either species of *Isotelus*; in fact, the majority of the specimens are in an exceedingly fragmentary condition, but several of these of very considerable proportions show the genal spine.

The general features of the two species can readily be seen in the figure of *I. gigas* (after Hall) given herewith. The following points brought out in Clarke's description apply to both species:

The cephalon and pygidium are elongate sub-triangular, the extremities subacute, slightly flattened or extenuate. The facial sutures meet at an acute angle at, or just behind the frontal margin. The glabella is obscurely defined, and more obscurely lobate, traces only of the lateral furrows being visible in an oblique light. The cheeks bear an intramarginal furrow, above which their general surface is elevated into a more or less conspicuous node, crowned by the eye. The occipital ring and furrow are quite obsolete. The axial furrows of the thorax are quite distinct, the axis itself broad, considerably more than one-third the width of the thorax. The lobation of the pygidium is very obscure, the dorsal furrows hardly distinguishable.

So far as I can determine, the common species in the Cincinnati region possesses the genal spines, and should therefore be referred to *Isotelus maximus.* Many of the fragments seen, however, do not show this critical part of the species, and in such cases no specific determination could be attempted. Specimens showing the spines were obtained at the following localities:

5.9A14....1.33A3....1.34A3, 4, 5, 15b, 16, 18b, 19-21.... 1.34C13....1.41C2-3, E6....1.12A2.

PROETUS SPURLOCKI Meek.

Plate LIV, fig. 13.

Proetus spurlocki Meek, 1872, Amer. Jour. Sci., 3d series, III, p. 426. (Not figured.)

"General form, exclusive of the spines of the cephalic shield, ovate-subelliptic, with moderate convexity. Cephalic shield having the form of half an ellipse divided through its shorter diameter, its posterior margin being straight, and its anterior narrowly rounded; posterior lateral angles produced into long sharp spines, that extend back nearly or quite the entire length of the thorax; glabella a little less than one-third the breadth of the posterior part of the head, separated from the cheeks on each side by a well defined furrow, but without having the neck furrow behind distinctly marked; other characters of the glabella unknown; eyes sublunate, nearly their own length in advance of the posterior margins of the cheeks.

"Thorax apparently shorter than the head, showing in the specimen examined only seven segments (one or two being probably concealed by the slipping backward of the cephalic shield); mesial lobe moderately prominent, scarcely equalling the breadth of the lateral lobes anteriorly, and tapering more rapidly backward, with its segments not arching forward. Lateral lobes less convex than the middle one; pleurae nearly straight and transverse, and furrowed for a little more than half way out, with their outer extremities merely rounded in front, and nearly rectangular behind, without any distinct backward curvature.

"Pygidium semicircular, scarcely one-half as long as the cephalic shield, and provided with a smooth flattened margin; mesial lobe moderately prominent, narrower than the lateral, tapering posteriorly, where it terminates rather abruptly, without passing quite upon the flattened margin, showing only very obscure traces of five or six segments on its anterior half. Lateral more depressed than the mesial one, and with flattened margins rather more than one-third the breadth at the anterior end of each, and each showing obscure traces of six or seven furrowed segments.

"Entire surface smooth.

"Length of a specimen apparently very slightly shortened by the slipping of the cephalic shield a little back upon the thorax, 0.33 inch; breadth at the widest part across the posterior part of the head, 0.25 inch; length of head, 0.27 inch; do. of pygidium, 0.11 inch.

"Until I saw the published figure of *Proetus parviusculus* Hall, I had thought it possible that this might be the same, although it did not seem to agree in several characters with those mentioned in the previously issued description of that species. On comparing it with the figure of that form, however, it will at once be seen to present well marked differences. In the first place, its cephalic shield is decidedly longer in proportion to its breadth, and more narrowly rounded in front; while the posterior lateral spines of its cheeks are nearly or quite twice the proportional length of those in *P. parviusculus.* Its eyes are also placed decidedly farther forward, and its neck segment is much less distinctly defined. When we come to its thorax, we also see equally well marked differences, its pleurae not being curved backward and falcate as in that species, nor having their furrows extending so far outward. It almost certainly has one or two segments less, though the slight slipping backward of the cephalic shield leaves some little room for doubt on this point. I have, however, also an inferior specimen before me, belonging to the collection of Dr. H. H. Hill of Cincinnati, believed to belong to this species, and this certainly has only eight thoracic segments. Again, the pygidium of our species differs in having distinctly flattened, smooth and very obscure furrowed segments on the lateral lobes, that do not extend out upon this border, while upon that of *P. parviusculus* the segments are strongly defined, without furrows, and extend very nearly or quite to the border, so as scarcely to leave any flattened margin.

"The specific name is given in honor of T. W. Spurlock, Esq., of Cincinnati, who discovered some of the new fossils loaned to the Ohio Survey, and is well known in that city for his long devotion to the study of the natural sciences."—Meek, *loc. cit.*

The above description needs no supplementing. I have a fragment referable to this species from the base of the Lorraine at Manchester Station, Indiana. 1.34C13. The type is from 100 ft. below the tops of the hills at Cincinnati, O.

TRINUCLEUS CONCENTRICUS (Eaton).

Plate LIV, fig. 11.

Nuttainia concentrica Eaton, 1832, Geol. Textbook, p. 34, pl. i, fig. 2.

"Fillet in the form of a semi-ellipse cut in the direction of its transverse diameter, and truncated so as to present the two ends of the fillet in the line of the same diameter; punctures of the fillet in about 4 or 5 concentric arcs, separated by alternating arcs of fine elevated ridges; middle lobe of the head narrower than the side lobes, more prominent, and tapering posteriorly; whole animal short-ovate; side lobes wing-like, flat, with very narrow joints. The head is found in great numbers in the transition limerock of Glenn's Falls, and in the wacke variety of transition argillite on the Champlain Canal, between Waterford and the Mohawk. Three figures, 7 A, B, C, Plate IV, of Brogniart, found in Russia by Stokes, are the heads of this species; but Stokes did not find the bodies. Fig. 6 of the same is probably a species of this genus. The head excludes all these species from the genus Asaphus."—Eaton, *loc. cit.*

The pitted margin of the cephalon and three conspicuous pear-shaped lobes, and the long straight genal spines, are sufficient to distinguish this species, which is unlike any other Trilobite in the same formations. The thoracic segments are rarely seen, but fragments of the cephalon are abundant at several horizons in the Eden shales.

5.9A2, 4....1.34C5....1.38A23, 29.

ANNELIDA.

DESCRIPTION OF SPECIES.

CORNULITES RICHMONDENSIS (Miller).

Plate XLII, fig. 5.

Tentaculites richmondensis Miller, 1874, Cincinnati Quarterly Journal of Science, vol. I, p. 234, fig. 28.

"Tube free or detached, straight, conical, gradually tapering from the aperture to an obtuse point. Surface marked by strong encircling annulations or constrictions, which are crossed by very fine, regular, longitudinal striae.

"Length of a specimen about one inch; diameter at the aperture about $1\frac{1}{4}$ lines; width of the annulations at the aperture about half line, which gradually diminish to less than one-quarter that size, and become nearly obsolete as they approach the closed end of the tube.

"While some of the tubes appear to be slightly curved toward the point, yet the numbers observed, which are broken across each other and across coral stems and other inequalities of the surface with which they came in contact, indicate that the tubes were very slightly, if at all, flexuous.

"They were found in the upper part of the Cincinnati group, near Richmond, Indiana, by Mrs. M. P. Haines, on slabs, dispersed and scattered in every direction, in great abundance. They do not appear to have ever been attached to each other or to any other body, nor to have lived in clusters, yet on one particular slab, not more than six inches square, in the cabinet of Mrs. Haines, there may be more than a hundred tubes scattered, wholly without order, in every direction. A slab, however, of that size, with a dozen of these tubes on it, may be regarded as a reasonably good specimen.

"The tubes have a marked resemblance to *conchiolites ? flexuosa* (Hall), though they may be readily distinguished by their much larger size, straight instead of curved form and free instead of attached habit. While I think that the latter are not always curved nor always attached, yet that is the general condition in which they are found, but this species does not appear to have ever been attached, and it is doubtful whether it was in the least flexuous in its living state."—Miller, *loc. cit.*

The type as indicated above is from Richmond, Indiana. The specimens which I have referred to this species are usually rather smaller than indicated above, though in other respects they conform to the description. Miller's figure does not show any longitudinal striae, though he mentions such in his description. All of the specimens in my collection show the longitudinal striae very plainly. An example of this species is shown natural size on the upper end of the slab containing a number of specimens of *Dalmanella meeki* from Versailles, Indiana. (Pl. XXXIII, fig. 6g.) If I have correctly identified it, it occurs rather abundantly in the lower part of the Richmond formation, wherever the latter is exposed in Indiana.

1.34A3, 4, 7, 8, 9, 10, 11....1.41B1, 1.12E3.

CORNULITES TENUISTRIATUS (Meek and Worthen).

Tentaculites tenuistriatus Meek and Worthen, 1865, Proc. Acad. Nat. Sci. Phila., 1865, p. 254. (Not figured.)

"Shell attaining a rather large size, gradually tapering, and a little curved; annulations large, prominent, rather obtuse near the smaller end; separated by rounded constrictions of about 0.10 inch breadth at the larger extremity of a specimen one inch or more in length. Surface marked by numerous, very fine, regular, closely arranged longitudinal striae, most distinctly marked in the rounded depressions between the annulations. Aperture circular.

"Length, 1.16 inches; breadth at the aperture, measuring upon one of the rings, 0.25 inch; do. between the rings, 0.19 inch; space occupied by four rings and the three intervening spaces at the larger end, 0.30 inch; while the same space includes six rings at the smaller end.

"This species resembles rather closely the enlarged figure of a form from the same horizon, referred by Prof. Hall to his *T. flexuosa* (pl. 78, fig. 26, Palaeont. N. Y. Vol. 1): but its annulations are sharper, and its longitudinal striae more crowded; while the natural size of the New York species is much smaller.

"Dr. Shumard has also described, under the name *T. incurvus* (Missouri Report, p. 195), a similar form, though his species is much smaller, with more crowded rings, while it also differs in having minute annular striae."—Meek and Worthen, *loc. cit.*

Reported in Kindle's list from Richmond, Indiana. I have not succeeded in obtaining a figure or specimen of this species.

CORNULITES FLEXUOSUS (Hall).

Plate XXXII, fig. 11.

Tentaculites ? flexuosus Hall, 1847, Paleontolgy of New York, vol. I, p. 92, pl. xxix, figs. 6 a-d.

"Tubes single or aggregate, adhering, more or less curved at the tip or along the whole length; surface marked by strong annulations, which are crossed by fine longitudinal striae; annulations somewhat irregular; interior distinctly septate; septa with the concave sides upwards.

"The mode of growth and the interior structure here developed give us more information regarding the habits of this hitherto doubtful fossil than we have before possessed. If the species in question is a true TENTACULITES, of which perhaps we may have some doubt, it appears to have been developed like many of the corals, viz., a simple tube affixed at the base, occupied by an animal which secretes calcareous matter, building up the walls of the cell, and extending across it transverse septa as the tube became elongated. The structure of the tube, however, allies it more nearly with Crinoideans than with Corals; and it is probable that it was inhabited by a simply constructed animal of the same order.

"The specimen fig. 1*a* [of Hall's paper] first attracted my attention by its curved tip, showing that it must have been attached to some other body. A further careful search among a large number of specimens from Lowville enabled me to discover the attached group, which shows that an exudation of calcareous matter attached them firmly to the shell, while a group of the cells of *Chaetetes lycoperdon* have commenced their growth on the same.

"I have referred this, with some hesitation, to the genus TENTACULITES, both on account of its general form and mode of adhering to other bodies, as well as from its internal structure, which, however, has not heretofore been shown in the true TENTACULITES. All the other species known in our strata are straight, rigid, and gradually tapering to a point, always separate, and never known as adhering to other bodies."—Hall, *loc. cit.*

The type is from the Trenton Limestone, Lowville, New York. The specimen of which I give a figure is from the upper part of the Utica formation on Tanner's Creek, near Manchester, Indiana. This is, if I am not mistaken, the form commonly known as *C. conica*. The reference of this species to the worms instead of the genus *Tentaculites* now rests upon secure evidence.

PLATE I.

Page

Beatricea undulata Bill.. 700

1. General view of specimen. N.*

Beatricea nodulosa 701

1a. Longitudinal section. N.

1b. Transverse section. N.

Labechia montifera Ulr... 704

2. Portion of a large specimen which has overgrown an Orthoceras. U.**

2a. Vertical section of a specimen from Waynesville, O. U.

2b. Transverse section of the same. U.

Calapoecia cribriformis Nich..................................... 701

3. View of a small specimen. Natural size. N.

3a. Portion of the surface, enlarged. N.

3b. Interior of a corallite, showing the septa and mural pores, enlarged. N.

3c. Section of a specimen from Richmond, Indiana, showing the tabulae and mural pores. x about 1.5.

Columnaria alveolata Goldf....................................... 703

4. Longitudinal section of a specimen from Osgood, Indiana, natural size.

4a. Transverse section of the same specimen.

Protarea vetusta Hall.. 705

5. Surface of a portion of a specimen from Richmond, Indiana. x 2.

Streptelasma divaricans Nich..................................... 707

6. Small specimen with a single lateral bud. N.

6a. Another specimen with four corallites. N.

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*Figure after Nicholson.

**Figure after Ulrich.

Plate I.

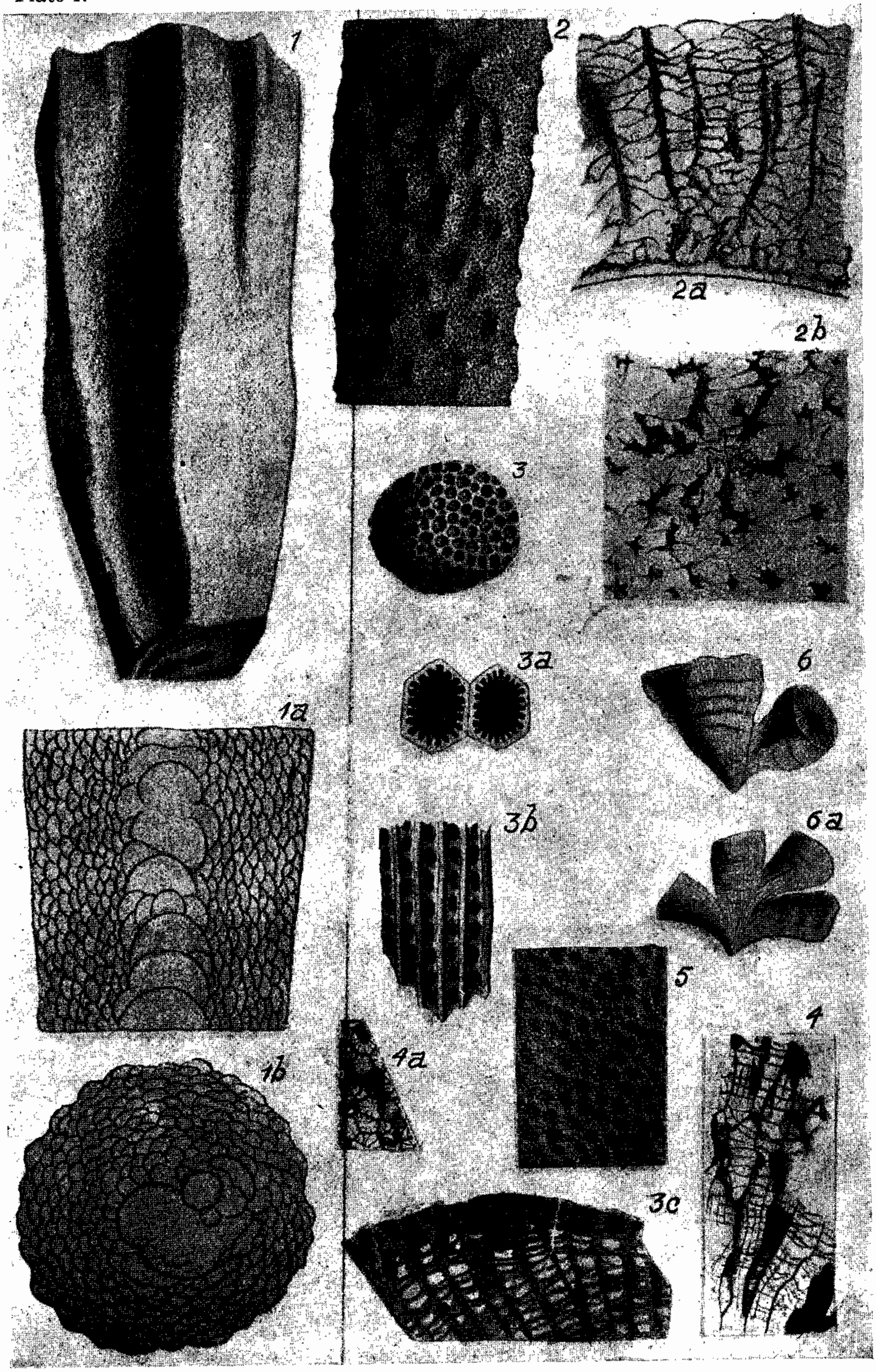

PLATE II.

Page

Tetradium minus Safford.. 709

1. Surface of a portion of a specimen from Weisburg, Indiana. x 2.

1a. View of a broken surface showing the corallites in longitudinal section. x 2.

1b. Transverse section. x 18.

1c. Longitudinal section. x 18.

Streptelasma rusticum Bill.. 708

2. Specimen from Tanner's creek, Indiana, natural size.

2a. Transverse section of a specimen from Versailles. x 2.

2b. Longitudinal section of the same. x 2.

Strephochetus richmondensis Miller................................ 706

3. Polished slab, showing several specimens, natural size. Ml.*

3a. Longitudinal section. x 100. Ml.

3b. Transverse section. x 100. Ml.

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*Figure after Miller.

Plate II.

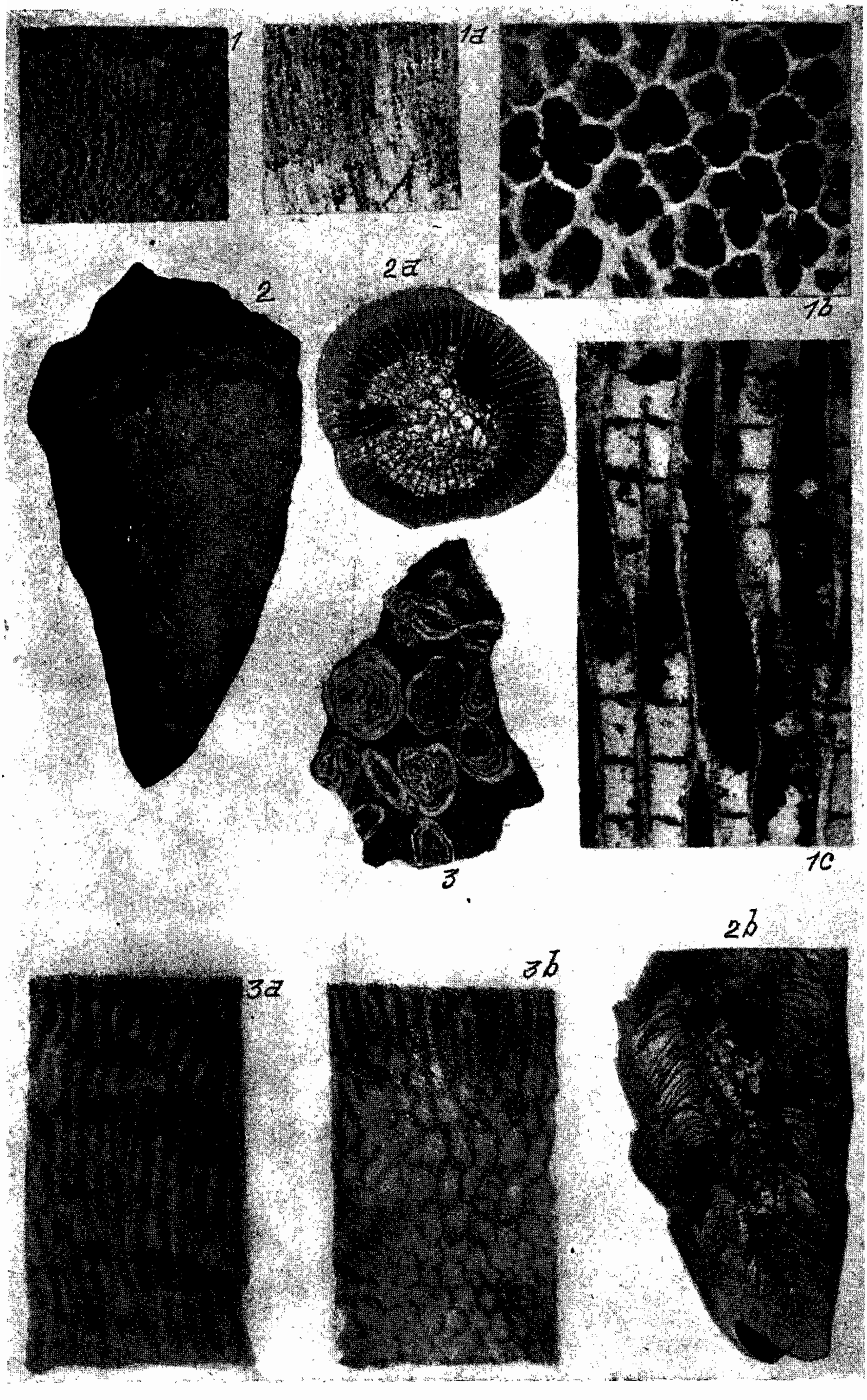

PLATE III.

*Figures after Meek.

†Figure after Miller and Dyer.

Plate III.

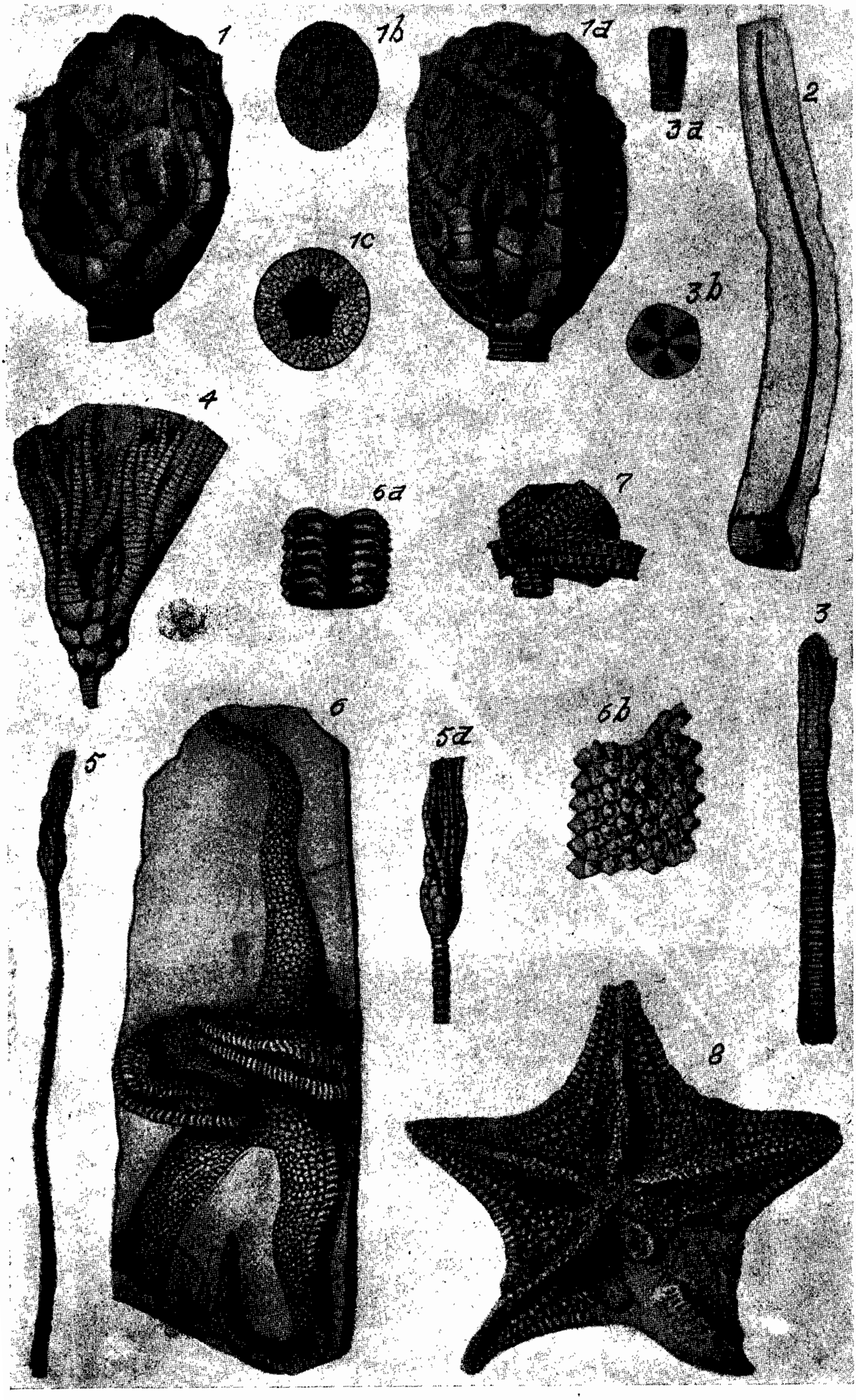

PLATE IV.

Page

Xenocrinus baeri Meek.. 734

1. Specimen consisting of the arms and pinnulae only. M.

1a. Side view of the body and arms with the pinnulae. M.

Dendrocrinus casei Meek.. 717

2. Anterior view with portions of some of the arms and part of the column attached. M.

2a. Posterior view of young individual. Dyer collection. M.

2b. End view of the column. M.

Lichenocrinus tuberculatus Miller.. 730

3. Upper surface of a specimen from Richmond, Indiana. Haines collection. x 2. Miller.

Lichenocrinus pattersoni Miller.. 729

4. Top view of a specimen from Kentucky opposite Cincinnati. Miller. x 2.

4a. Same, natural size. Miller.

Lichenocrinus dyeri Hall.. 729

5. A specimen showing the upper side of the disc with its numerous very small pieces, and the base of its appendage in the middle. Dyer collection. M.

Lepadocrinus moorei Meek.. 727

6. Side view of body and part of column. x 1. M.

6a. Another view of same showing the anal opening. M.

6b. Top view, enlarged. M.

Iocrinus subcrassus Meek and Worthen.. 726

7. Posterior view of a specimen showing the anal series of pieces. M.

7a. Side view of body and arms with a piece of the column. M.

Glyptocrinus dyeri Meek.. 722

8. Posterior view of body and lower part of arms. M.

Glyptocrinus decadactylus Hall.. 720

9. Side view of the body and lower part of the arms of an unusually fine specimen. M.

Ectenocrinus simplex Hall.. 720

10. Oblique posterior view of a specimen. M.

10a. Side view of body and portion of the arms of a specimen that seems to have had the upper portion of its arms broken away and subsequently restored during the life of the animal. M.

Lepidodiscus faberi Miller.. 728

11. Enlarged view of an imperfect specimen on the shell of a brachiopod. Ml.

Lichenocrinus crateriformis Hall.. 728

12. Basal layer of platform showing its upper or inner structure exposed by the removal of the disc plates and internal laminae. x 2. M.

12a. Upper side of disc with the long appendage removed. x 3. M.

12b. Side view of a similar specimen. x 2 M.

Plate IV.

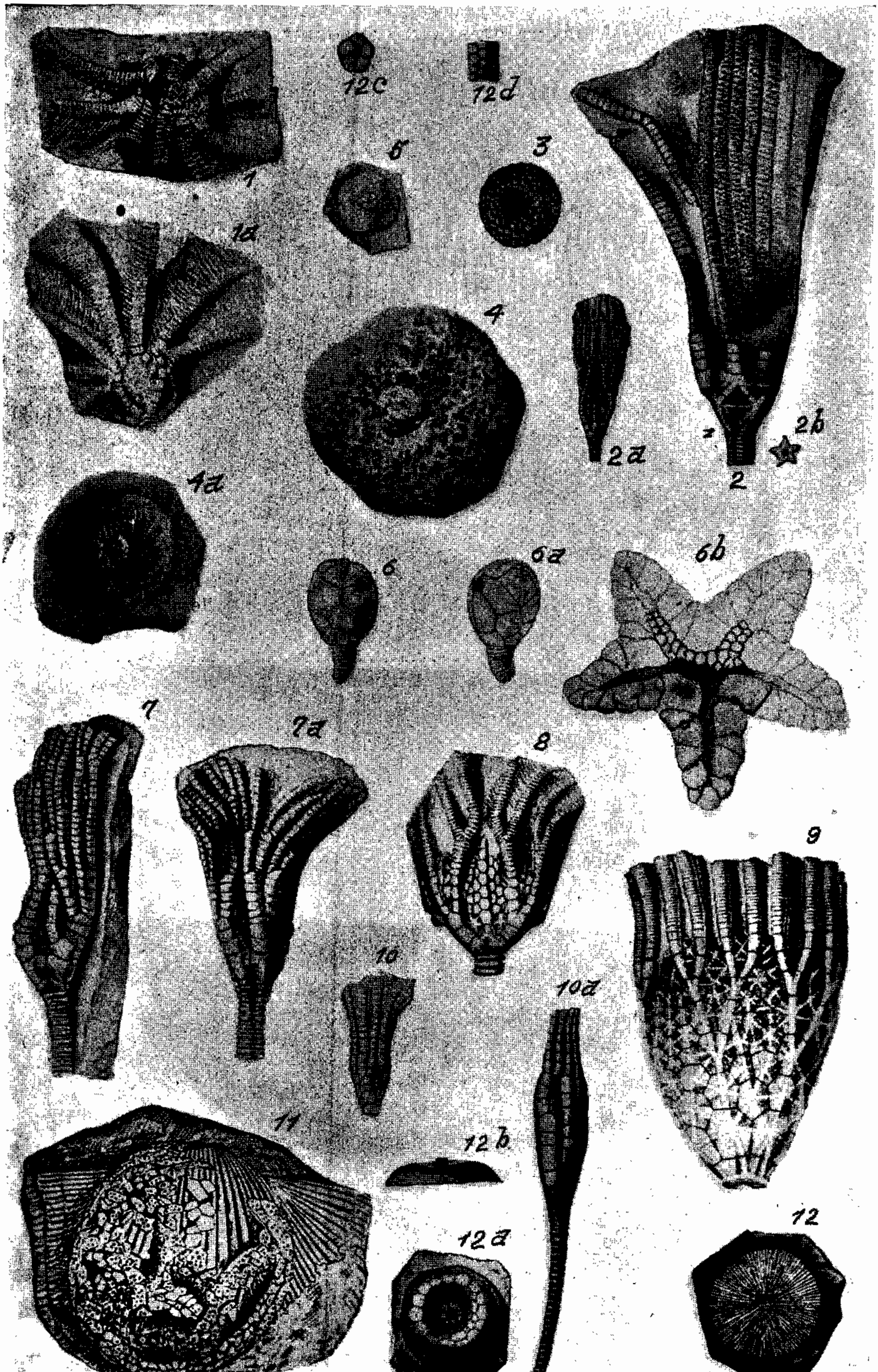

PLATE V.

Plate V.

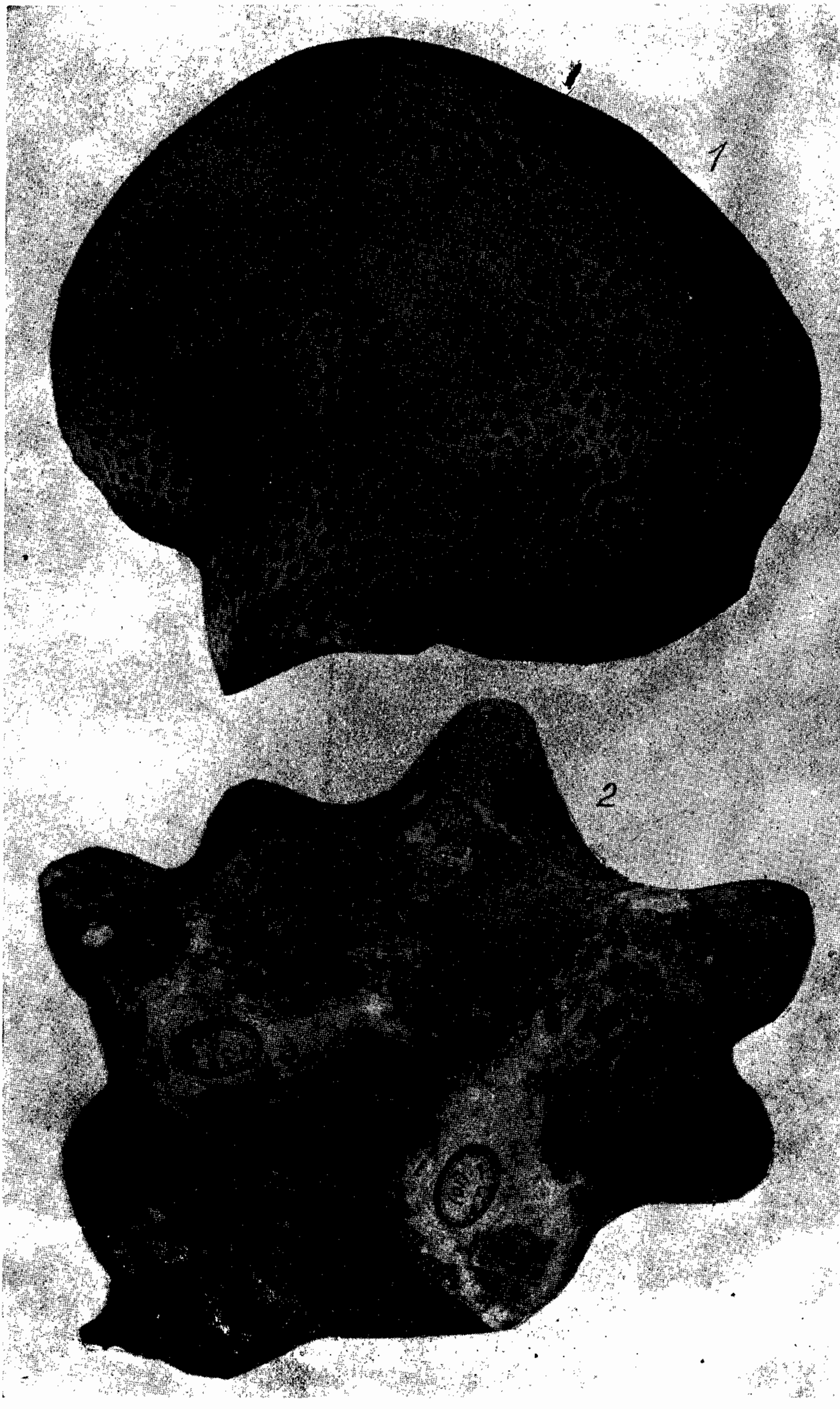

PLATE VI.

Page

Amplexopora cingulata Ulrich.. 758

1. Longitudinal section. x 18. U.

1a. Tangential section near the surface. x 18. U.

Amplexopora septosa var. *multispinosa* Cumings.................... 765

2. Longitudinal section of a specimen from the Upper Utica at Milton, Indiana. x 18.

2a. Tangential section of the same. x 18.

2b. Portion of the surface. x 9.

Amplexopora petasiformis Nicholson.............................. 760

3. Tangential section. x 18. N.

3a. Longitudinal section of the same. x 18. N.

Amplexopora pustulosa Ulrich.................................. 761

4. Longitudinal section. x 18. U.

4a. Tangential section. x 18. U.

4b. Portion of the surface. x 9. U.

Amplexopora robusta Ulrich.................................... 762

5. Longitudinal section. x 18. U.

5a. Tangential section. x 18. U.

5b. Portion of the surface. x 18. U.

Amplexopora septosa Ulrich..................................... 763

6. Longitudinal section of a specimen from the base of the Lorraine at Vevay, Indiana. x 18.

6a. Tangential section cutting the deeper portion of the mature region. x 18.

6b. Tangential section of the mature region. x 20.

Plate VI.

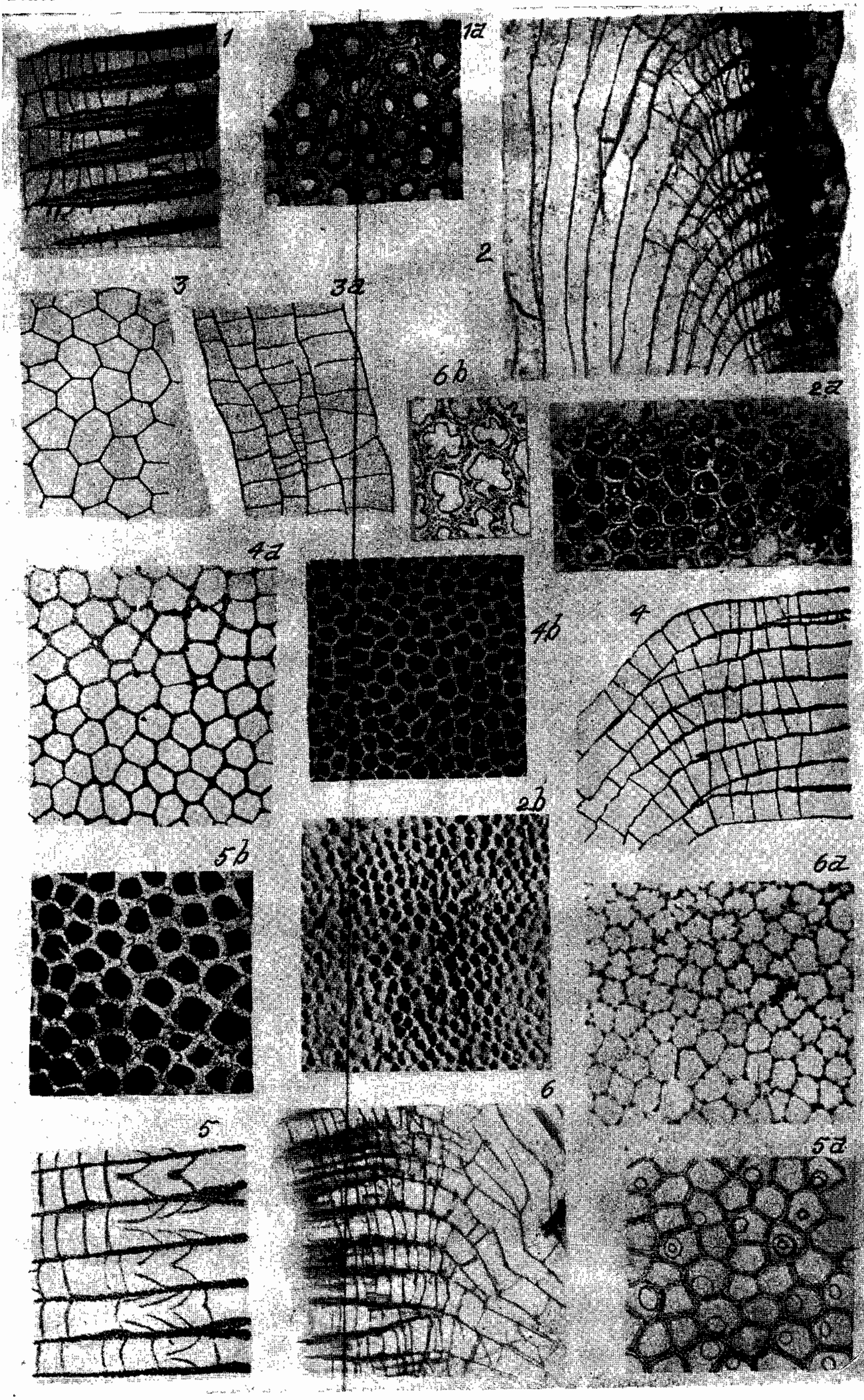

PLATE VII.

Plate VII.

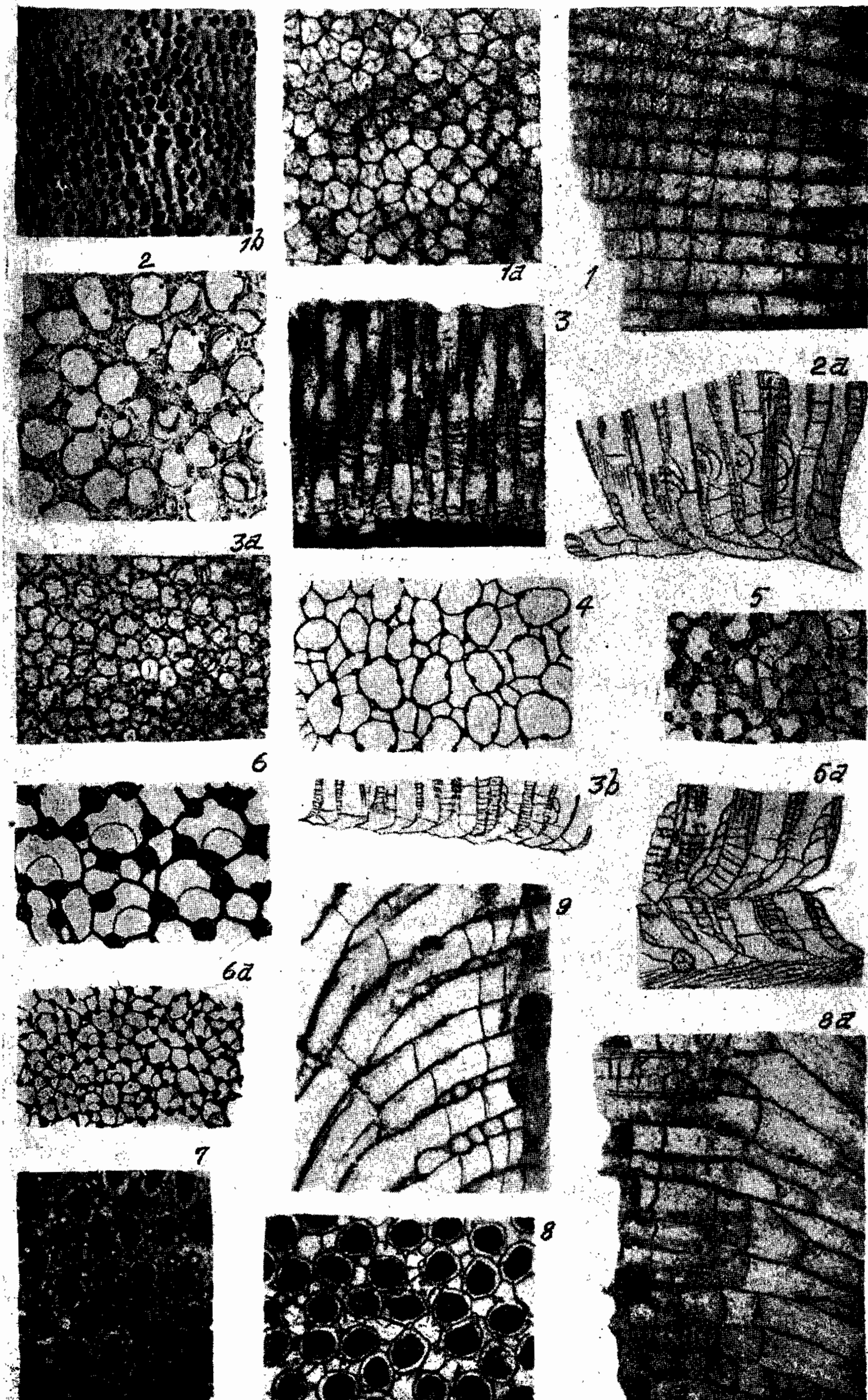

PLATE VIII.

Page

Batostoma jamesi Nicholson.................................... 775

1. Surface of the same specimen as Pl. VII, fig. 8. x 9.

Batostoma implicatum Nicholson.................................... 774

2. Surface of a specimen of this species from Guilford, Indiana. x 9.

Batostoma varians James.................................... 778

3. Surface of a specimen from near Weisburg, Indiana. x 9.

3a. Tangential section of the mature region of the same. x 18.

3b. Tangential sections of the mature and immature regions of another specimen. x 18. U.

Batostoma variabile Ulrich.................................... 777

4. Longitudinal section of a specimen of this species. U.

Bythopora meeki James.................................... 783

5. Longitudinal section of a specimen from the top of the Waynesville formation near Weisburg, Indiana. x 18.

5a. Tangential section of the mature region of another specimen. x 18.

Bythopora gracilis Nicholson.................................... 782

6. Tangential section of the mature region of a specimen from the Lorraine at Lawrenceburg, Indiana. x 18.

6a. Surface of a specimen of this species. Enlarged. N.

6b. Surface of the species still further enlarged. N.

Bythopora delicatula Nicholson.................................... 781

7. Portion of the surface of a specimen, enlarged. N.

Bythopora arctipora Nicholson.................................... 780

8. Portion of the surface of this species greatly enlarged. N.

Callopora andrewsi Nicholson.................................... 785

9. Portion of the surface of a specimen of this species from Lawrenceburg, Indiana. x 9.

9a. Surface of a specimen enlarged. N.

Callopora onealli var. *communis* James.................................... 788

10. Portion of the surface of a specimen from Manchester Station, Indiana. x 9.

Callopora dalei Edwards and Haime.................................... 792

11. Portion of the surface of a specimen from Manchester Station, Indiana. x 9.

Plate VIII.

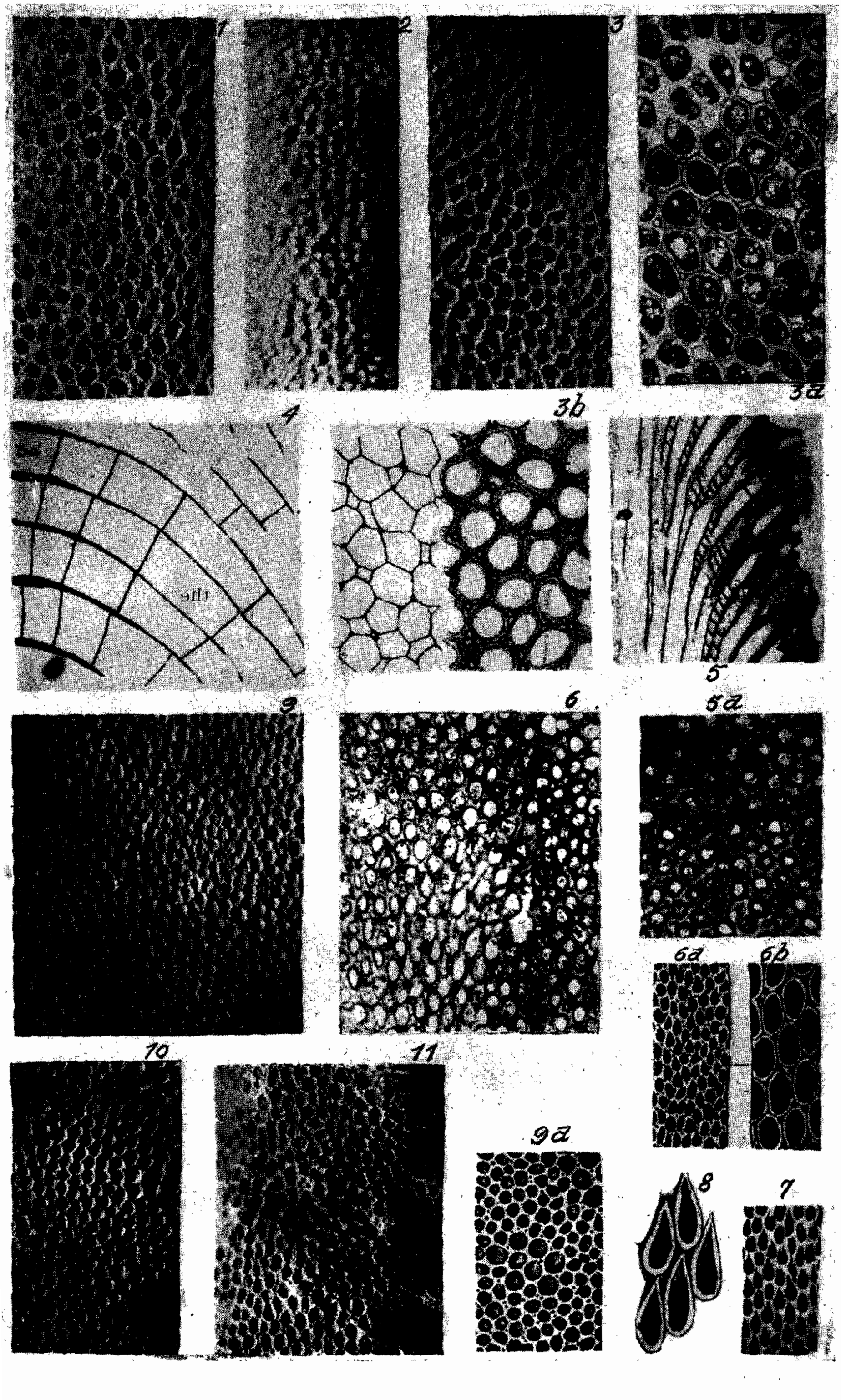

PLATE IX.

Page

Callopora frondosa n. sp. 785

1. Tangential section of a specimen from the Whitewater division at Richmond, Indiana. x 18.

1a. Longitudinal section of the same. x 18.

Callopora nodulosa Nicholson 786

2. Longitudinal section. x. 18. N.

2a. Cross section. x 18. N.

2b. Tangential section. x 18. N.

2c. Portion of the surface. x 18. N.

Callopora onealli James 786

3. Portion of a specimen from Guilford, Indiana. x 9.

3a. Longitudinal section. x 18. N.

3b. Tangential section. x 18. N.

Callopora onealli var. *sigillaroides* Nicholson 789

4. Longitudinal section of a specimen of this species. x 18.

Callopora ramosa d'Orbigny 790

5. Longitudinal section of a specimen from Lawrenceburg, Indiana. x 18.

5a. Surface of same. x 9.

Callopora cf. *ramosa* .... ——

6. Longitudinal section of a specimen from Weisburg, Indiana, from the top of the Liberty formation. x 18. The surface characters of this specimen are practically identical with those of typical *C. ramosa*.

Plate IX.

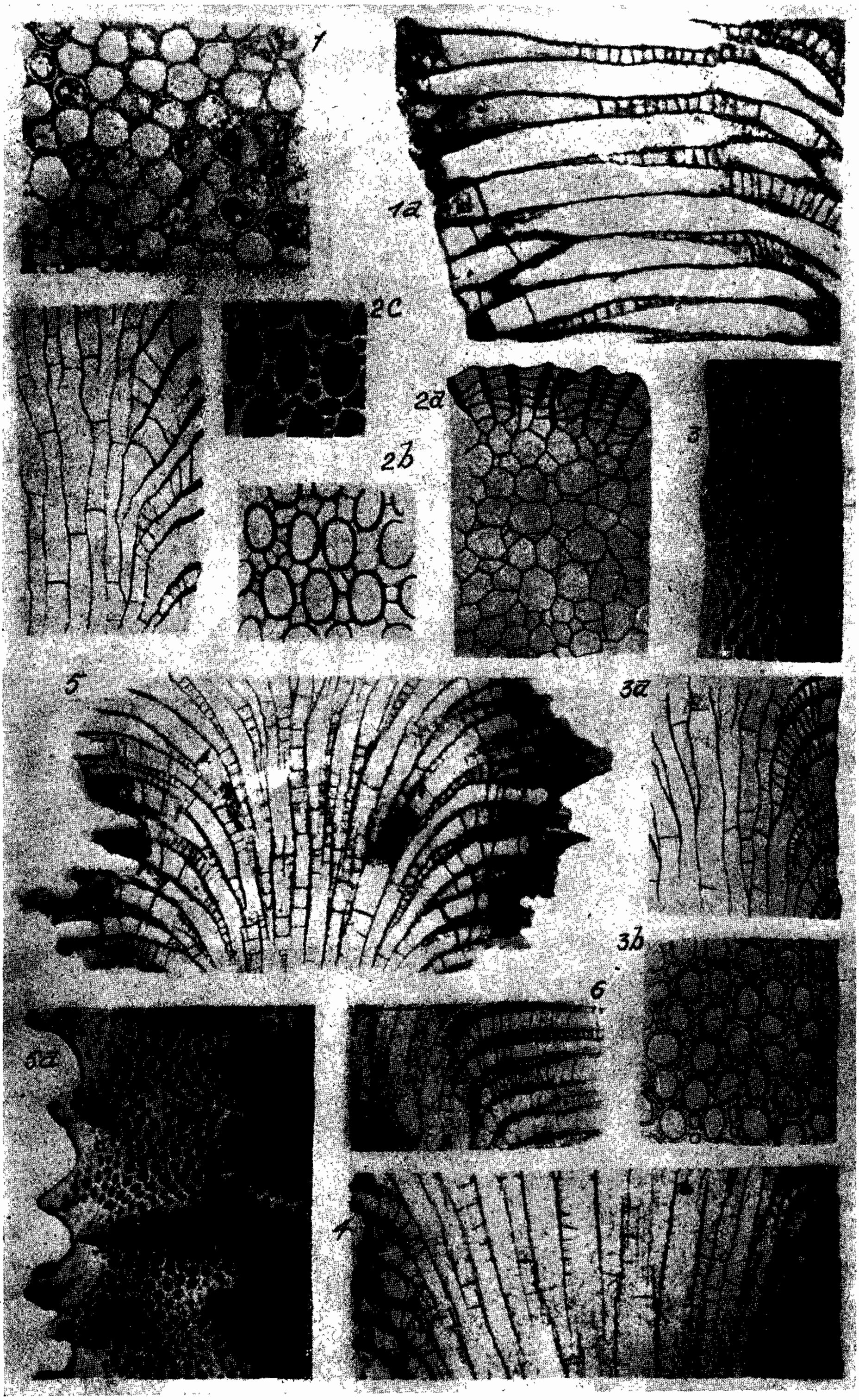

PLATE X.

Page

Callopora ramosa d'Orbigny.. 790

1. Cross section of the stem of the type in the collection of d'Orbigny. x 10. A. P.*

Callopora ramosa var. *rugosa* Edwards and Haime.................. 793

2. Longitudinal section of a specimen of this species from near the top of the hill back of Vevay, Indiana. x 18.

Callopora cf. *rugosa*... ——

3. Tangential section of a specimen from the Whitewater division at Richmond, Indiana, having the external characters of *C. rugosa*. x 18.

3a. Longitudinal section of the same. x 18.

Callopora subplana Ulrich.. 795

4. Longitudinal section of a specimen from the upper Eden near Guilford, Indiana. x 18.

4a. Tangential section of another specimen from a position slightly higher up in the section. x 18.

Callopora subnodosa Ulrich... 796

5. Longitudinal section of a specimen from near Weisburg, Indiana. x 18.

5a. Surface of a similar specimen from the same locality. x 9.

Calloporella circularis James...................................... 797

6. Vertical section of a specimen, natural size. U.

6a. Surface of a portion of the zoarium. x 18. U.

6b. Vertical section. x 18. U.

6c. Tangential section of the mature region. x 35. U.

Ceramoporella distincta Ulrich..................................... 799

7. View of a portion of the surface of a specimen from near Guilford, Indiana. x 9.

*Annales de Paleontologie.

Plate X.

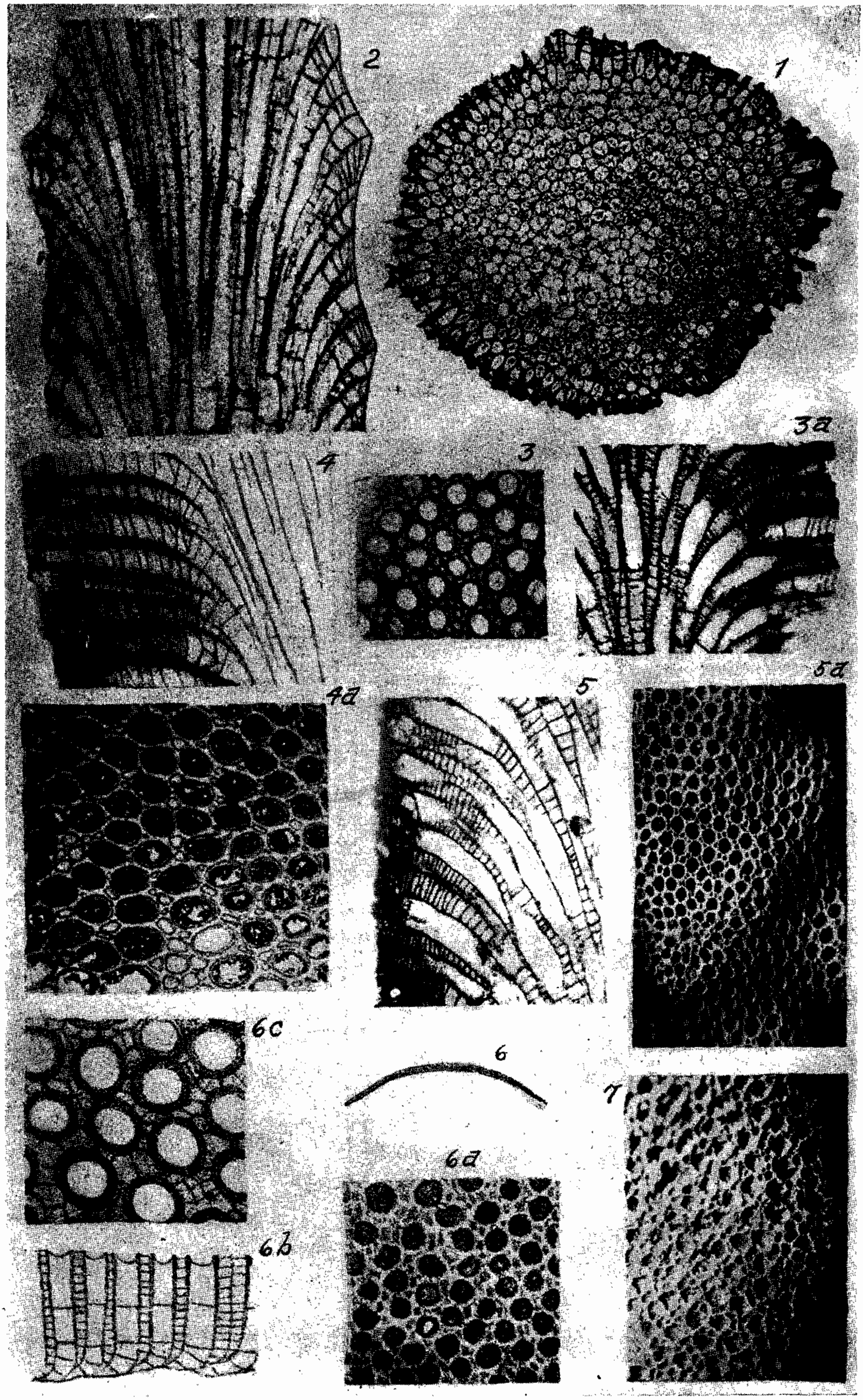

PLATE XI.

Plate XI.

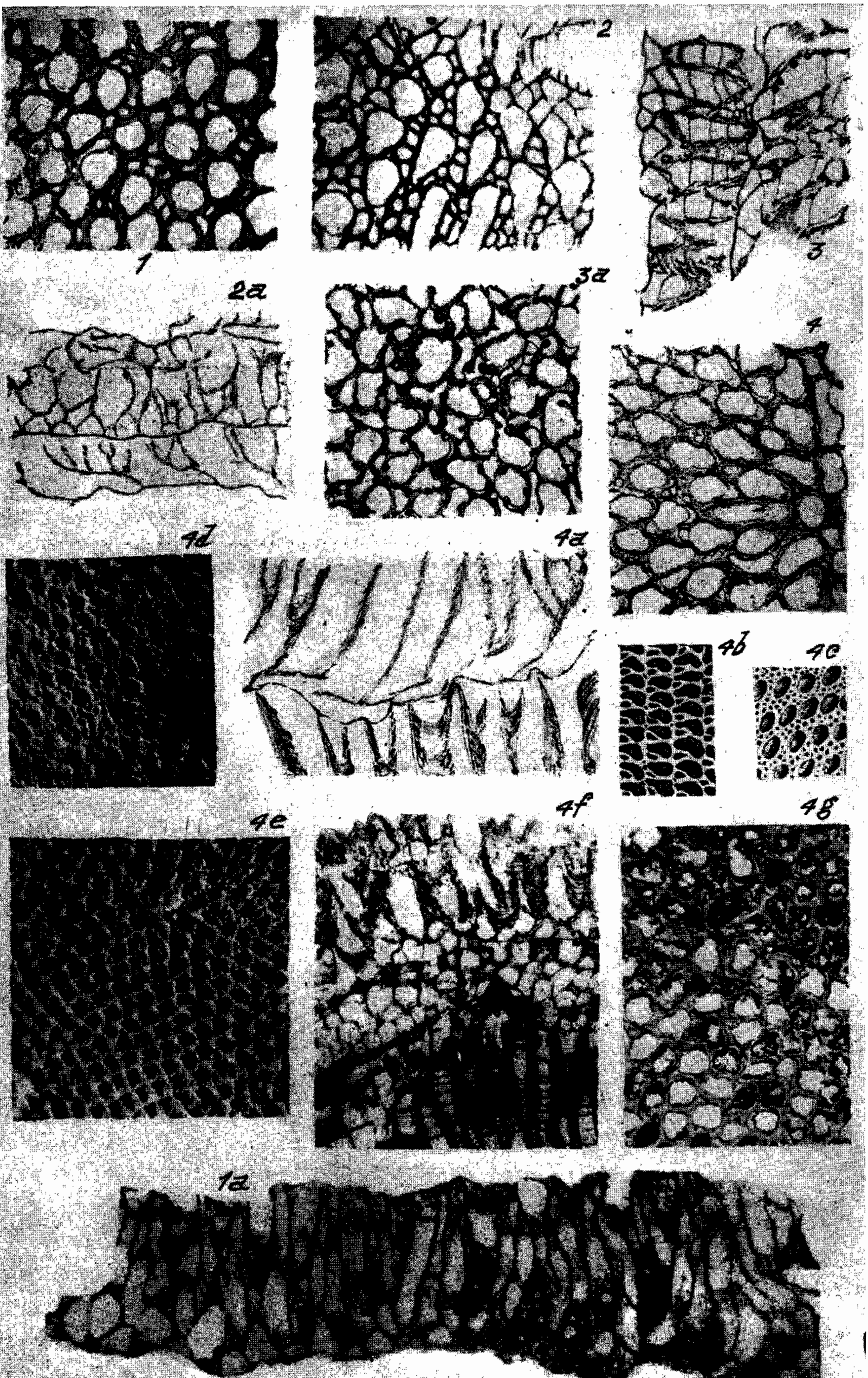

PLATE XII.

Page

Chiloporella flabellata Ulrich 802

1. Transverse section of this species. x 18. U.

1a. Longitudinal section. x 18. U.

1b. Surface of a specimen from Manchester, Indiana, referred to this species. x 9.

Coeloclema alternatum James 803

2 and 2a. Longitudinal sections. x 18. U.

2b. Portion of a transverse section. x 18. U.

2c. Portion of the surface. x 9. U.

2d. Portion of the surface of a specimen from Vevay, Indiana. x 9.

Coeloclema commune Ulrich 804

3. Tangential section. x 18. U.

3a. Tangential section of a specimen from the Utica formation at Vevay, Indiana. x 18.

3b. Portion of the surface, showing one of the maculae. x 9. U.

3c. Portion of the surface of a speceimen from Guilford, Indiana, showing one of the maculae. x 9.

Constellaria constellata Dana 804

4. Portion of the surface of one of the star-like clusters that constitute the chief feature of the genus. U.

4a. Tangential section of the fully mature region. x 18. U.

4b. Tangential section of the immature region. x 18. U.

4c. Portion of a tangential section of the mature region. x 50. U.

4d. Longitudinal section. x 18. U.

4e. Portion of a tangential section of a specimen from the base of the Lorraine at Vevay, Indiana. x 18.

Plate XII.

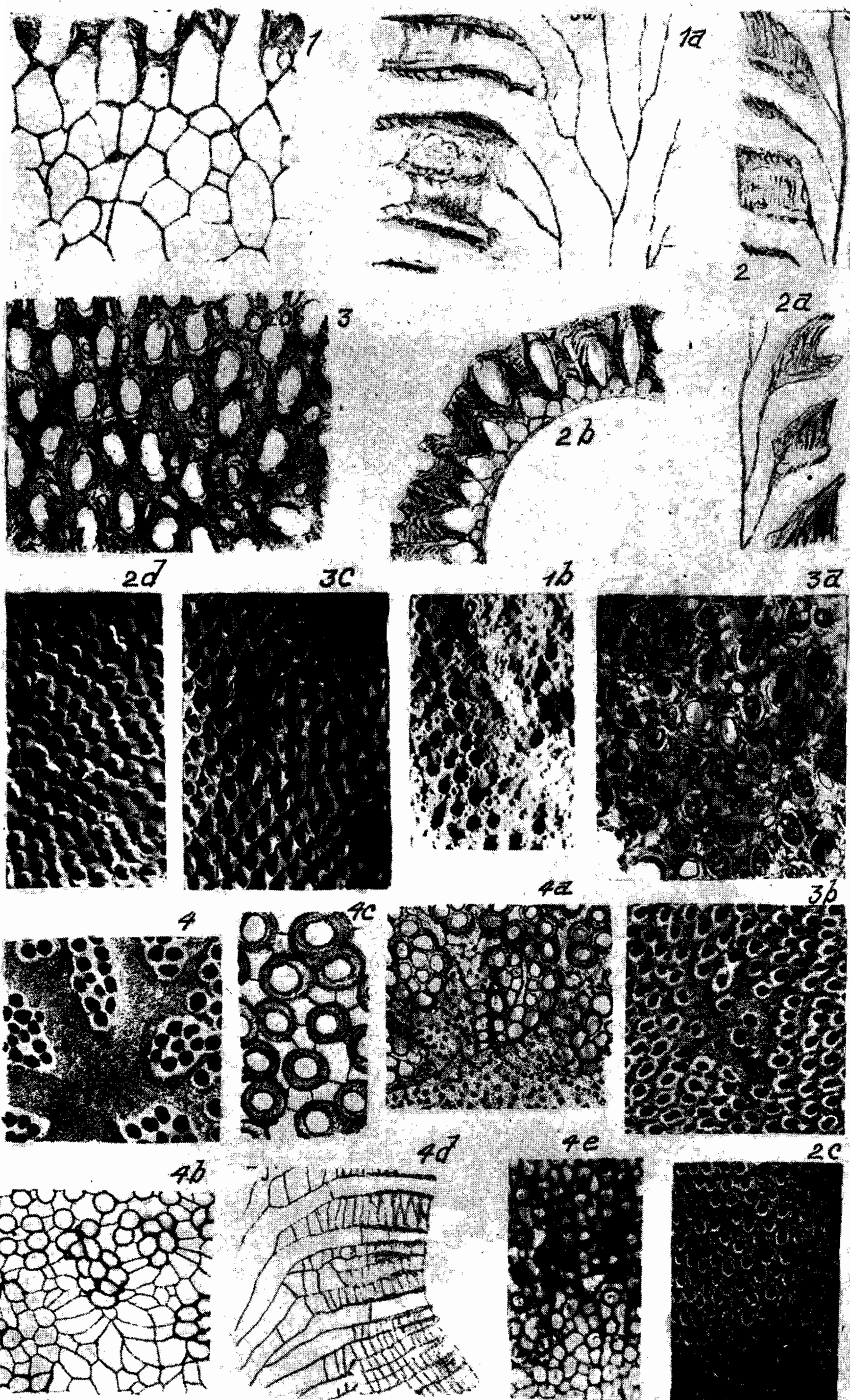

PLATE XIII.

Page

Constellaria polystomella Nicholson.................................... 808

1. Tangential section through one of the star-shaped maculae of this species. Weisburg, Indiana. x 18.

1a. Longitudinal section of same. x 18.

1b. Portion of the surface of a somewhat abraded specimen. The same as 1a and 1. x 9.

Constellaria limitaris Ulrich.. 806

2. Very perfectly preserved surface of a specimen from Weisburg, Indiana. x 9.

Dekayia appressa Ulrich.. 809

3. Tangential section of a specimen of this species from the collection of the Yale Museum. x 18.

Dekayia pelliculata Ulrich.. 818

4. Tangential section of a specimen from the Lorraine formation at Vevay, Indiana. x 18.

4a. Longitudinal section of the same. x 18.

Dekayia aspera Edwards and Haime.............................. 810

5. Longitudinal section of a very perfect specimen of this species in the Redfield collection of the Yale Museum. x 18.

5a. Tangential section of the mature region of the same. x 18.

5b. Surface of the same. x 9.

Dekayia magna Cumings.. 815

6. Tangential section of a specimen from the Lorraine at Lawrenceburg, Indiana, showing the small acanthopores. x 18.

6a. Longitudinal section of the same. x 18.

Plate XIII.

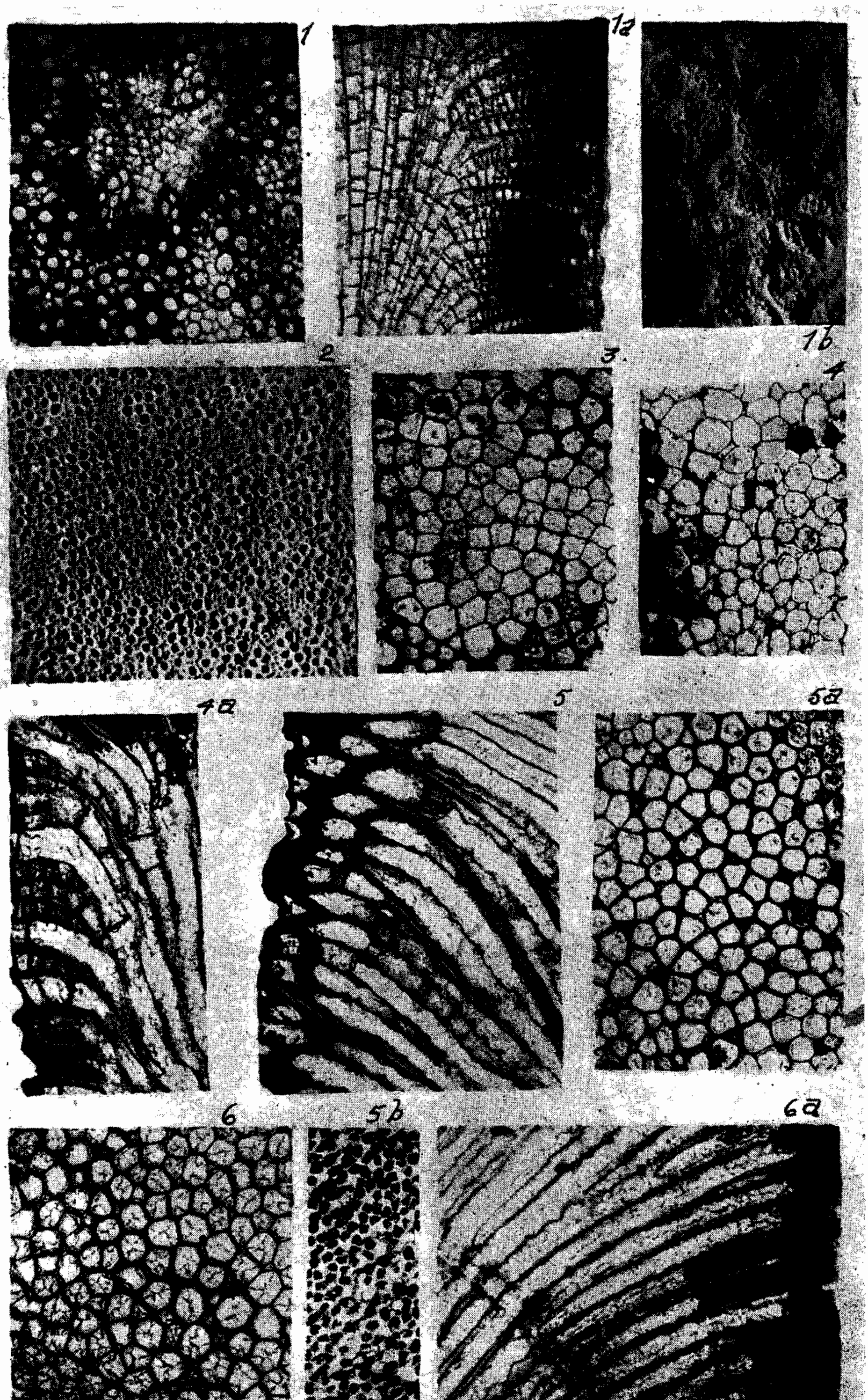

PLATE XIV.

Page

Dekayia frondosa var. *cystata* Cumings............................ 813

1. Tangential section of a specimen from the Lorraine formation at Vevay, Indiana. x 18.

1a. Longitudinal section of the same. x 18.

Dekayia ulrichi var. *robusta* Foord................................ 826

2. Longitudinal section of a specimen from the upper part of the Utica formation at Manchester Station, Indiana. x 18.

2a. Tangential section. x 18.

2b. Portion of the surface. x 9.

Dekayia obscura Ulrich.. 816

3. Tangential section of the mature region of a specimen in the collection of the Yale Museum. x 18.

3a. Portion of the surface of a specimen from Guilford, Indiana. x 9.

Dekayia ulrichi Nicholson... 824

4. Tangential section of a specimen from the upper Utica at Vevay, Indiana. x 18.

4a. Tangential section of the fully mature region of a specimen from near Guilford, Indiana. x 18.

4b. Surface of another specimen from Guilford, Indiana. x 9.

Dekayia cf. *ulrichi*.. ——

5. Tangential section of a small ramose species from the base of the Waynesville formation near Harmon's Station, Indiana, which may be a variety of this species. x 18.

Dekayia subfrondosa Cumings....................................... 821

6 and 6a. Portions of a tangential section cutting the submature region and showing the two sets of acanthopores. x 18.

6b. Longitudinal section of the same. Base of the Lorraine formation at Manchester Station, Indiana. x 18.

6c. Portion of the surface of same. x 9.

Plate XIV.

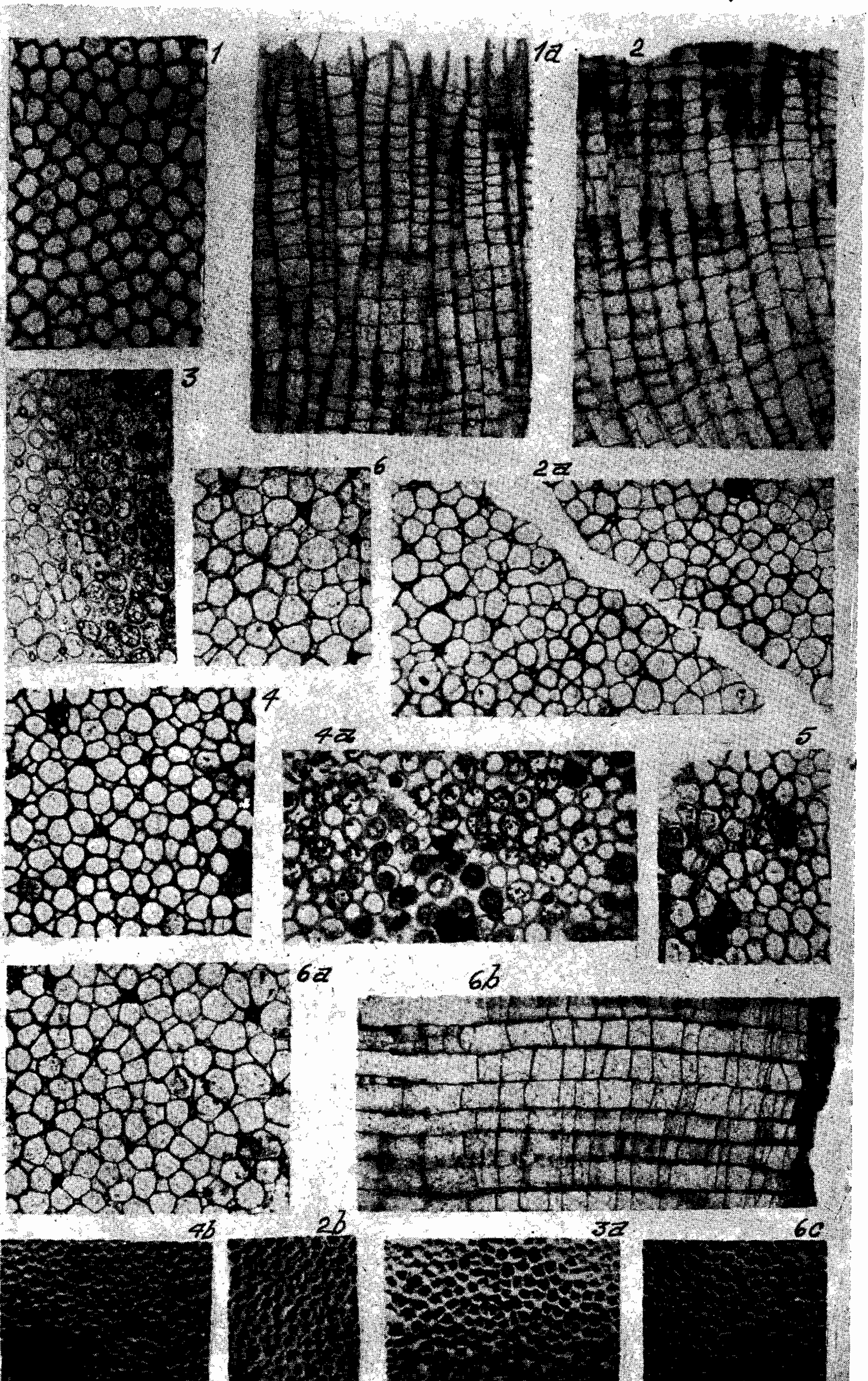

PLATE XV.

Page

Dekayia frondosa d'Orbigny.. 812

1. Longitudinal section of the type in the collection of d'Orbigny. x 10. A. P.

1a. Longitudinal section of a specimen from the Lorraine at Vevay, Indiana. x 18.

1b. Tangential section of the immature region of a specimen from the base of the Lorraine at Manchester Station, Indiana. x 18.

1c. Tangential section of the submature region of a specimen from the same locality and horizon. x 18.

1d. Tangential section of the mature region of a finely preserved specimen from Brookville, Indiana. x 18.

1e. Surface of same. x 9.

Dekayia inflecta Ulrich.. 814

2. Longitudinal section of a specimen in the Yale Museum, labeled by Mr. Ulrich. x 18.

2a. Tangential section of same. x 18.

Dekayia paupera Ulrich.. 817

3. Longitudinal section of the type. x 18. U.

3a. Tangential section of same. x 18. U.

Dekayia prolifica Ulrich.. 820

4. Tangential section of a specimen from the top of the Waynesville formation near Weisburg, Indiana. x 18.

4a. Longitudinal section of another specimen from the same place. x 18.

4b. Surface of a specimen from the Arnheim formation near Harmon's Station, Indiana. x 9.

Dekayia subramosa Ulrich.. 823

5. Tangential section of the submature region of a specimen from the Whitewater division at Richmond, Indiana. x 18.

5a. Longitudinal section of same. x 18.

Plate XV.

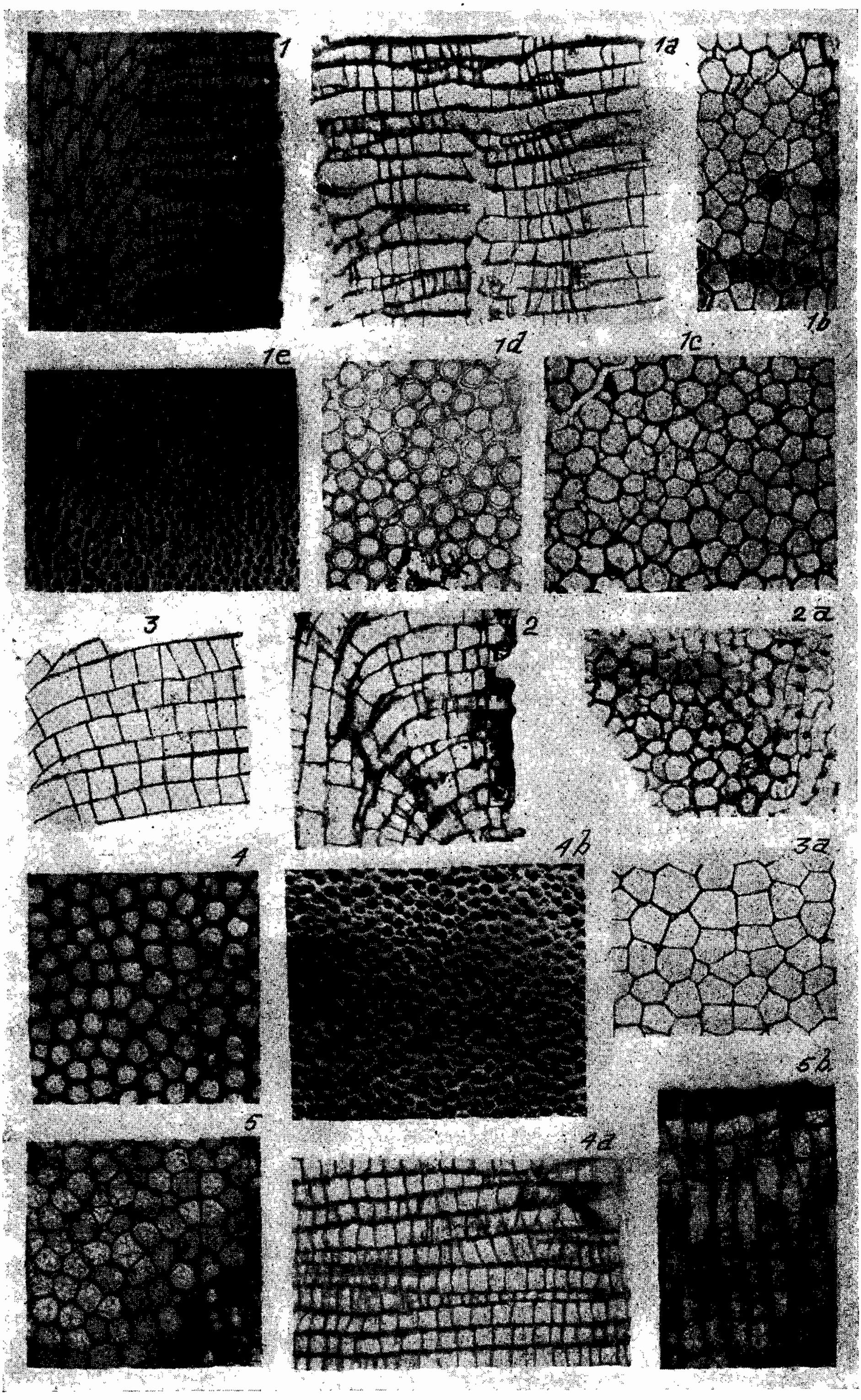

PLATE XVI.

Page

Dekayia subpulchella Nicholson.. 822

1. Tangential section of a specimen in the Yale Museum, labeled by Mr. Ulrich. x 18.

1a. Portion of the surface of a specimen showing the maculae of mesopores. N.

Dekayia sp.. ——

2. Longitudinal section of a specimen from the Whitewater division at Richmond, Indiana, showing the presence of an occasional acanthopore of great size in the immature region. x 18.

2a. Tangential section of the same. Showing an occasional acanthopore of extraordinary size. x 18.

Dekayia prolifica? 820

3. Longitudinal section of a specimen from Richmond, in which the walls of the zooecia are unusually thick. Probably a form of *D. prolifica*. x 18.

Eridotrypa simulatrix Ulrich.. 828

4. Tangential section of a specimen from the base of the Waynesville formation near Harmon's Station, Indiana. x 18.

4a. Longitudinal section of a typical example of the species. x 18. U.

4b. Surface of a specimen. x 9. U.

Escharopora falciformis Nicholson.................................... 830

5. Tangential section of a specimen from the Utica formation at Vevay, Indiana. x 18.

5a. Surface of a specimen from the Lower Lorraine at Manchester Station, Indiana. x 9.

Escharopora pavonia Edwards and Haime.............................. 832

6. Surface of a well preserved specimen from the base of the Lorraine at Manchester Station, Indiana. x 9.

Homotrypa Austini Bassler.. 838

7. Tangential section of the type. x 20. B.*

7a. Longitudinal section of the type. x 20. B.

7b. Portion of a tangential section. x 50. B.

*Figures after Bassler.

Plate XVI.

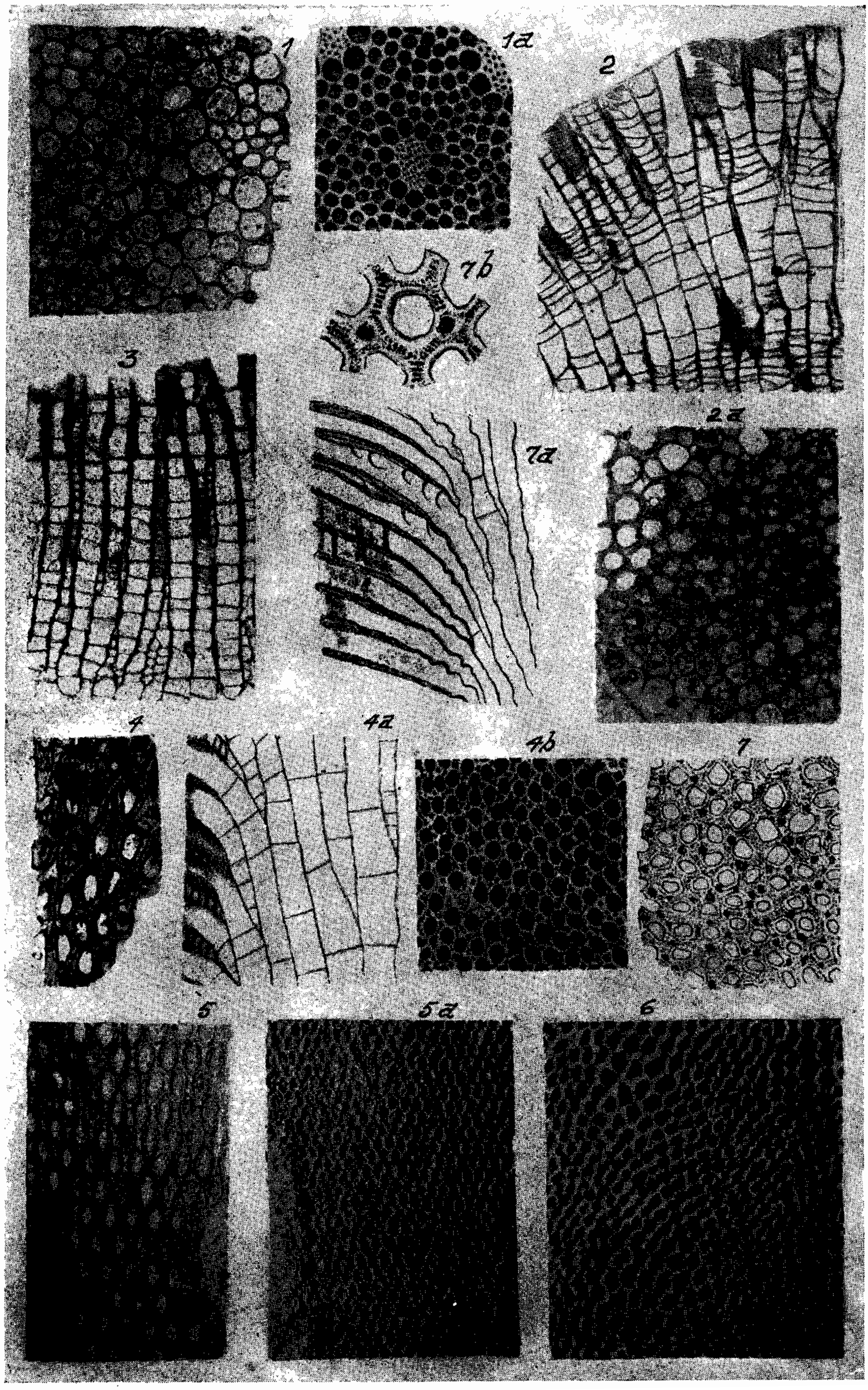

PLATE XVII.

Plate XVII.

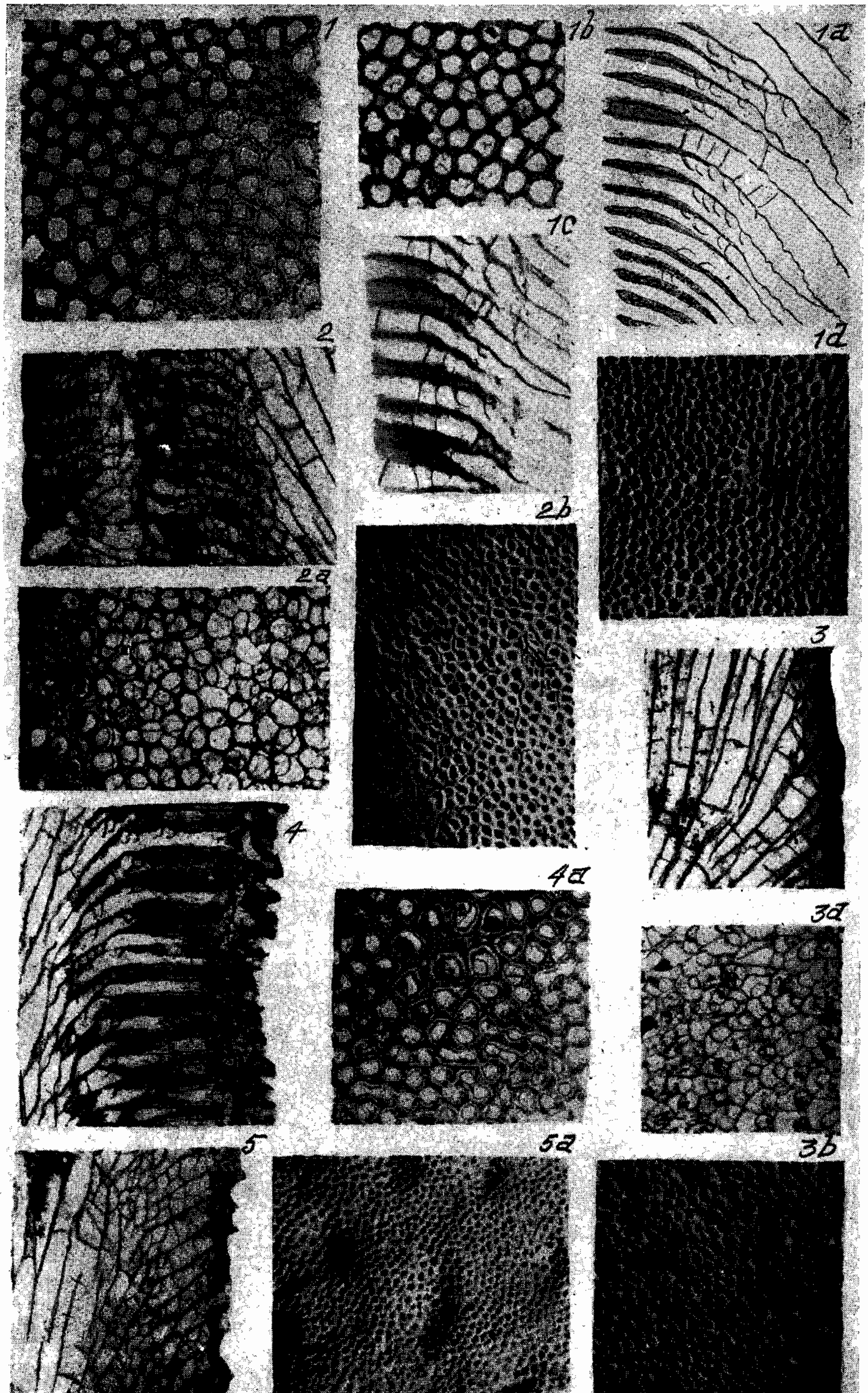

PLATE XVIII.

Page

Homotrypa flabellaris Ulrich.................................... 845

1. Longitudinal section of a typical specimen of this species, from the base of the Liberty formation near Weisburg, Indiana. x 18.

1a. Tangential section of same. x 18.

1b. Surface. x 9.

Homotrypa flabellaris var. *spinifera* Bassler........................ 847

2. Tangential section of a specimen of this variety, from the Whitewater division on Elkhorn creek, near Richmond, Indiana. x 18.

Homotrypa flabellaris var. *frondosa* Cumings....................... 846

3. Portion of the surface of the type. x 9.

3a. Tangential section of the same. x 18.

3b. Longitudinal section of the same. x 18.

Homotrypa curvata var. *praecipta* Bassler......................... 841

4. Portion of the surface of a specimen from the base of the Lorraine formation at Manchester Station. x 18.

Homotrypa nitida Bassler... 848

5. Longitudinal section of the type. x 20. B.

5a. Tangential section of the type. x 20. B.

Homotrypa nicklesi Bassler.. 847

6. Longitudinal section of the type. x 20. B.

6a. Tangential section of the type. x 20. B.

'late XVIII.

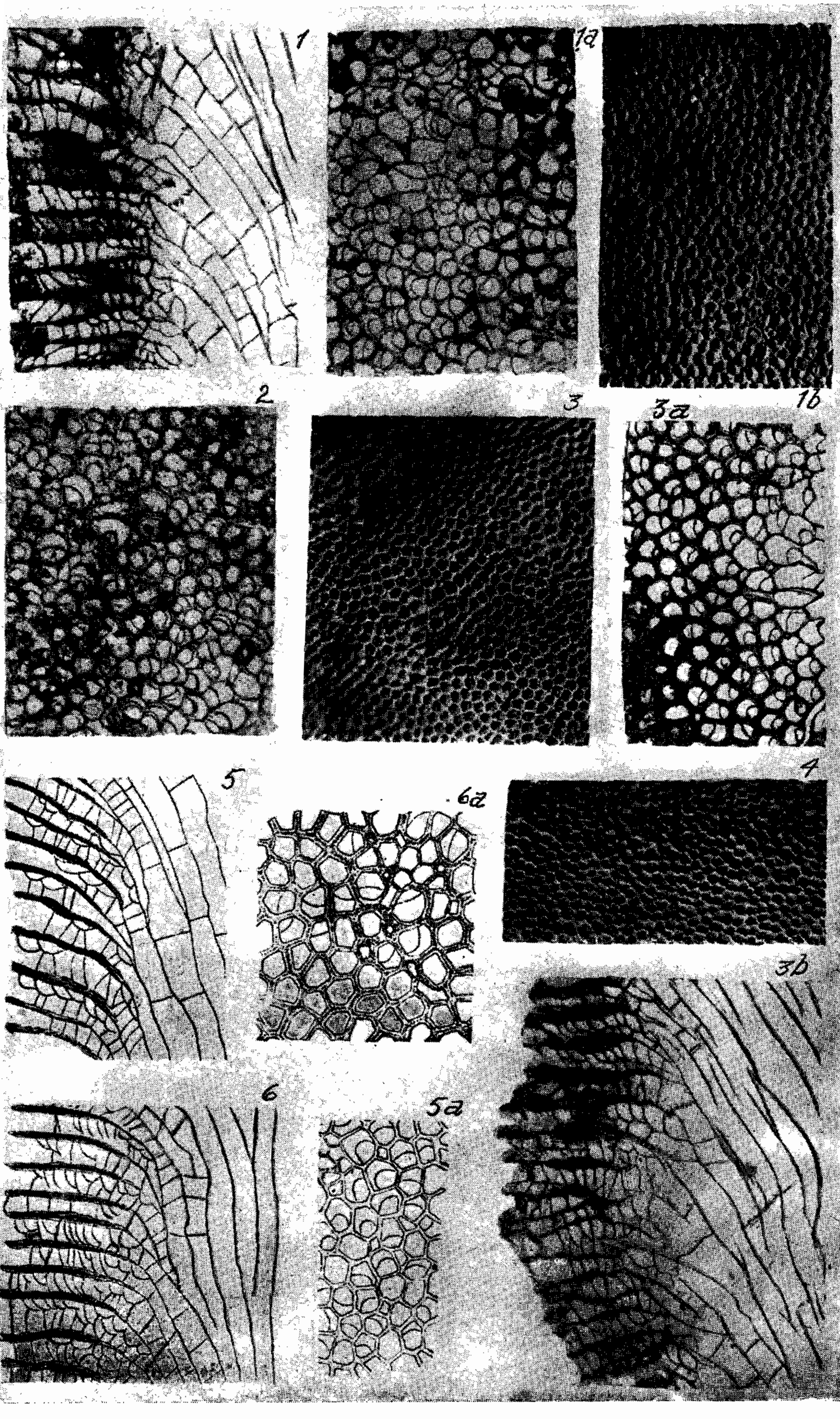

PLATE XIX.

Page

Homotrypa obliqua Ulrich.. 848

1. Tangential section of a specimen from the Lorraine formation at Lawrenceburg, Indiana. x 18.

1a. Longitudinal section of the same specimen. x 18.

1b. Cross section of the same specimen. x 18.

Homotrypa ramulosa Bassler.. 849

2. Longitudinal section. x 20. B.

2a. Portion of a longitudinal section. x 50. N. (This figure is inverted.)

2b. Tangential section. x 50. B.

Homotrypa wortheni James.. 849

3. Longitudinal section. x 20. B.

3a. Longitudinal section of a specimen from the extreme top of the Richmond series at Richmond, Indiana. x 18.

3b. Tangential section. x 20. B.

3c. Portion of a tangential section. x 50. B.

Homotrypa sp.. ——

4. Longitudinal section of a species found in the Liberty formation near Weisburg, Indiana. x 18.

4a. Tangential section of the same specimen. x 18.

Homotrypella cf. *rustica* Ulrich.. 851

5. Longitudinal section of a specimen from the Whitewater division at Richmond, Indiana. x 18.

5a. Tangential section of the same specimen. x 18.

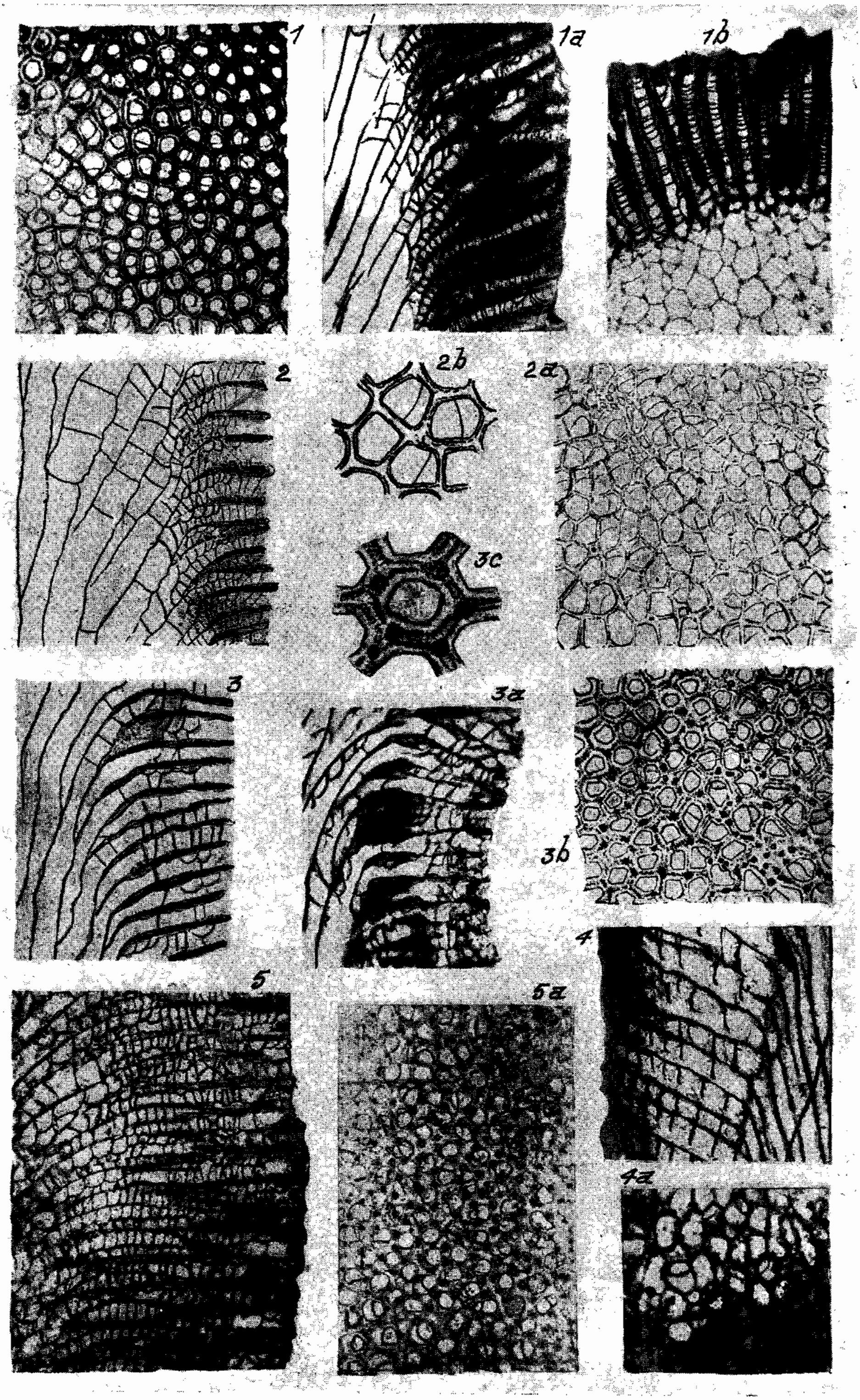
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PLATE XX.

Page

Leptotrypa calceola Miller and Dyer.................................. 853

1. Vertical section. x 18. N.

1a. Tangential section. x 18. N.

1b. Portion of the surface. x 18.

1c. Specimen of the entire zoarium, natural size. N.

Leptotrypa discoidea Nicholson.................................... 855

2. Tangential section. x 50. N.

2a. Portion of a longitudinal section. x 50. N. (This figure is inverted.)

2b. Tangential section. x 18. N.

2c. Longitudinal section. x 18. N.

2d-2f. Several views of a complete specimen, natural size. N.

Leptotrypa clavacoidea James.................................... 854

3. Transverse section. x 7. N.

3a. Portion of a tangential section. x 18. N.

3b. Portion of the surface. x 18. N.

3c. An average specimen of the natural size. N.

Monotrypella aequalis Ulrich.................................... 856

4. Longitudinal section of the type. x 18. U.

4a. Tangential section of the type. x 18. U.

4b. Surface of the type. x 18. U.

4c. Tangential section of a specimen from the Utica formation near Guilford, Indiana, which seems to possess the characters of this species. x 18.

Monticulipora epidermata Ulrich and Bassler....................... 857

5. Tangential section of a specimen from the Whitewater division at Richmond, Indiana. x 18.

5a. Tangential section, cutting the fully mature region of another specimen. x 18.

5b. The deeper portion of a longitudinal section of the last. x 18.

5c. Longitudinal section of the specimen of fig. 5. x 18.

Plate XX.

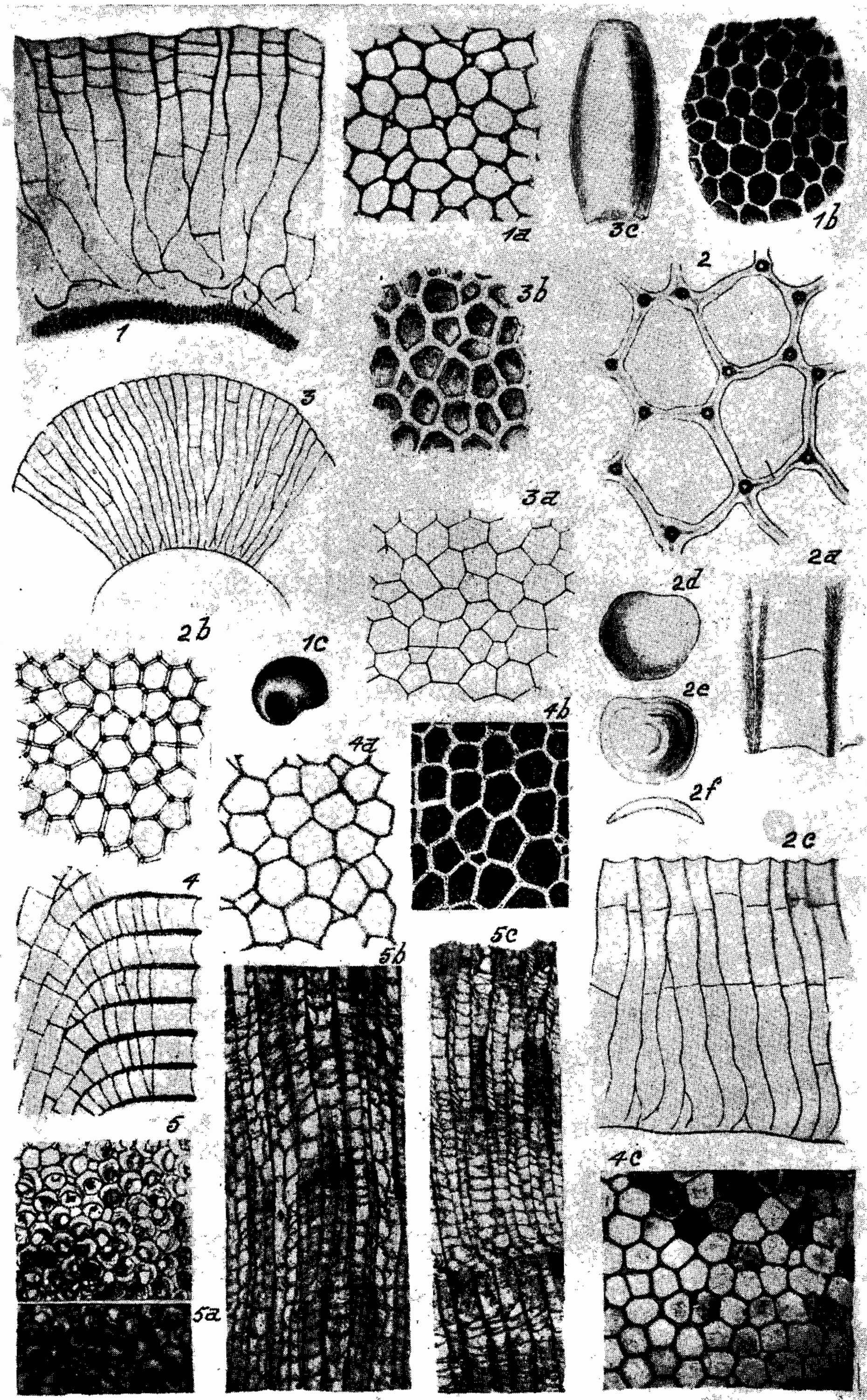

PLATE XXI.

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Monticulipora mammulata d'Orbigny.............................. 859

1. Longitudinal section of the type in the collection of d'Orbigny. x 10. A. P.*

1a. Longitudinal section of a specimen from the Lorraine, at Lawrenceburg, Indiana. x 18.

1b. Tangential section of the same specimen. x 18.

1c. Surface of a specimen from the same locality. x 9.

Monticulipora parasitica Ulrich.................................. 862

2. Vertical section of a specimen from the base of the Liberty formation, near Weisburg, Indiana. x 18.

2a. Tangential section of the same specimen. x 18.

2b. Portion of the surface of the same specimen. x 9.

Nicholsonella vaupeli Ulrich..................................... 863

3. Tangential section of the fully mature region of a specimen from the top of the Waynesville formation near Weisburg, Indiana. x 18.

3a. Deeper section of a specimen from the upper Lorraine at Vevay, Indiana. x 18.

3b. Longitudinal section of a specimen from the same locality. x 18.

3c. Surface of the specimen of fig. 3a. x 9.

Homotrypella cf. *rustica* Ulrich.................................. 851

4. Portion of the surface of this species. x 9.

*Annales de Paleontologie.

Plate XXI.

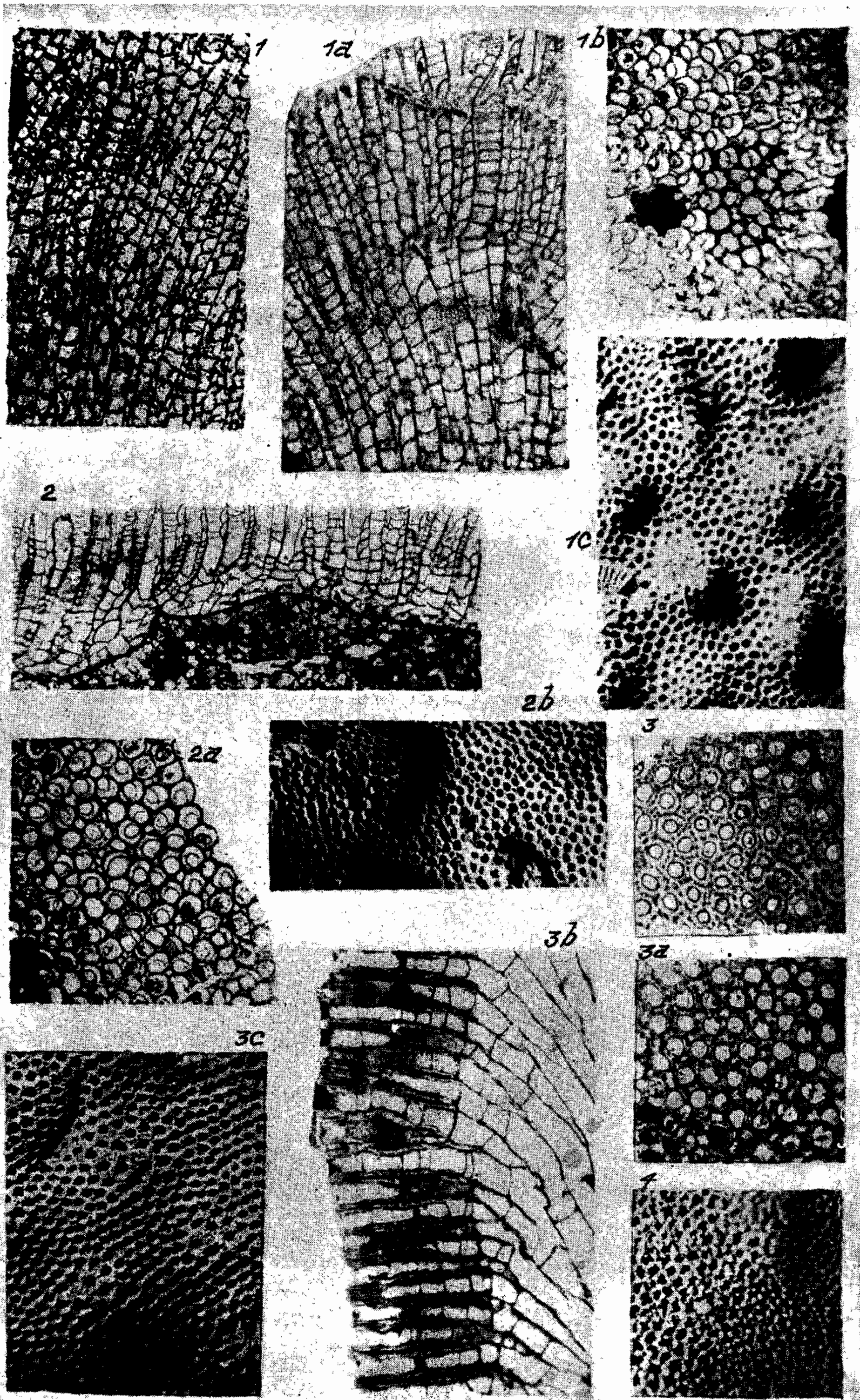

PLATE XXII.

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Peronopora pavonia d'Orbigny.................................... 866

1. Longitudinal section of a specimen from the Lorraine formation at Lawrenceburg, Indiana. x 18.

1a. Tangential section of the same specimen. x 18.

1b. Surface of a large and very perfect specimen from Lawrenceburg, Indiana. x 9.

1c. Longitudinal section of the type in the collection of d'Orbigny. x 10. A. P.

Peronopora vera Nickles.................................... 867

2. Longitudinal section of a specimen from the Utica formation near Rising Sun, Indiana. x 18.

2a. Tangential section of the same specimen. x 18.

2b. Portion of the surface of same. x 9.

Petigopora asperula Ulrich.................................... 868

3. Tangential section of the type. x 18. U.

3a. Vertical section. x 18. U.

3b. Surface. x 18. U.

3c. View of an entire specimen, natural size. U.

Petigopora gregaria Ulrich.................................... 869

4. Tangential section. x 18. U.

4a. Vertical section. x 18. U.

4b. Surface of a specimen. x 18. U.

4c. Several specimens of the natural size. U.

Petigopora petechialis Nicholson.................................... 870

5. Portion of a frond of *Dekayia frondosa* upon which are several specimens of this species. Natural size. N.

5a. One of the specimens magnified. N.

Plate XXII.

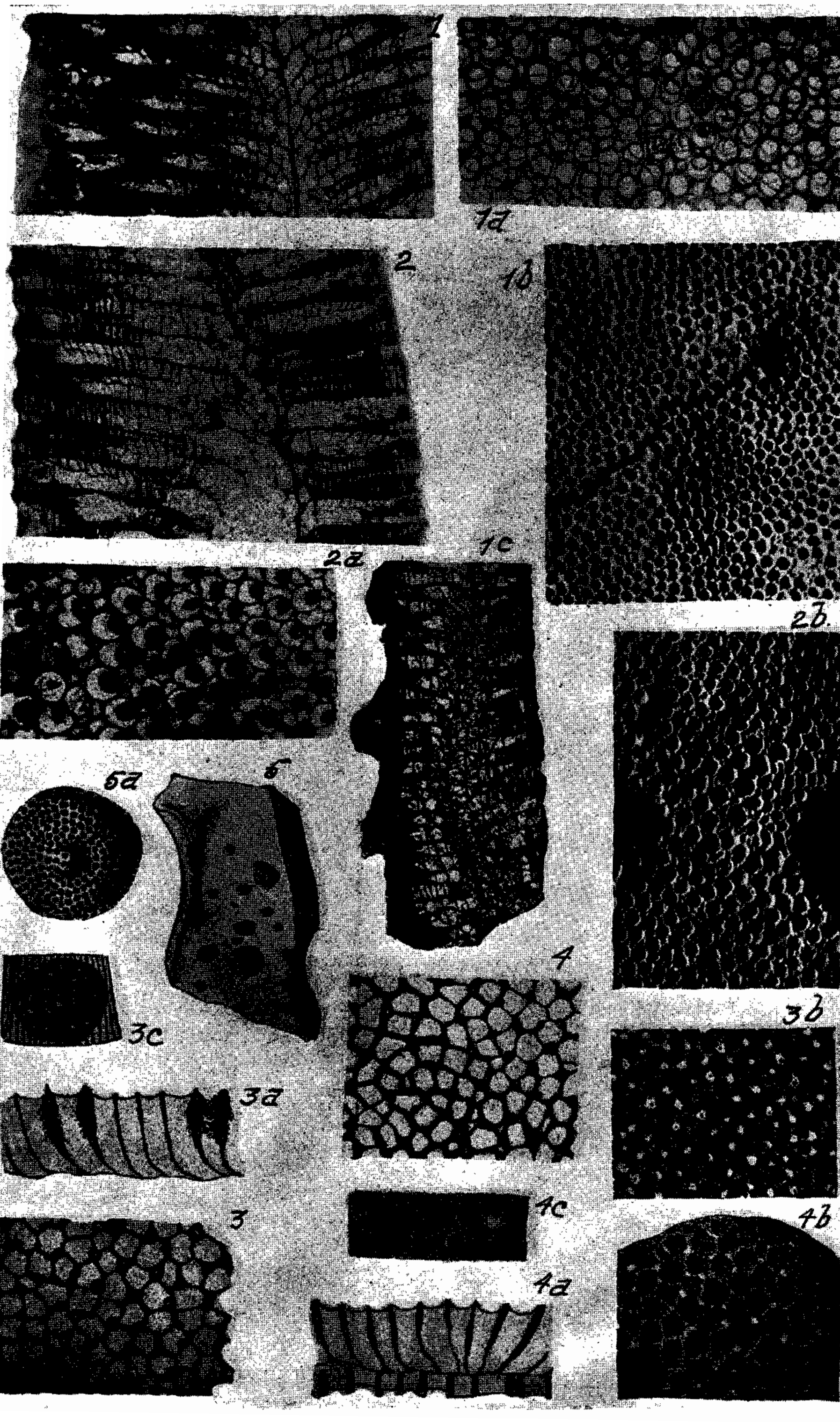

PLATE XXIII.

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Prasopora hospitalis Nicholson.................................... 871

1. Tangential section of a specimen from the top of the Waynesville formation near Weisburg, Indiana. x 18.

1a. Longitudinal section of the same. x 18.

1b. Portion of the surface of another specimen from the same locality and horizon. x 9.

Rhombotrypa crassimuralis Ulrich.................................... 876

2. Longitudinal section of the type. x 18. U.

2a. Tangential section. x 18. U.

2b. Portion of the surface. x 18. U.

2c. Section of a specimen from near the top of the Whitewater division at Richmond, apparently of this species. x 18.

Rhombotrypa subquadrata Ulrich.................................... 877

3. Longitudinal section of this species. x 18. U.

3a. Tangential section. x 18. U.

3b. Portion of the surface. x 18. U.

Rhombotrypa quadrata Rominger.................................... 877

4. Section across the stem of a specimen of this species from the base of the Liberty formation near Weisburg, Indiana. x 18.

4a. Tangential section of another specimen from the same place. x 18.

4b. Portion of the surface of the last. x 9.

Plate XXIII.

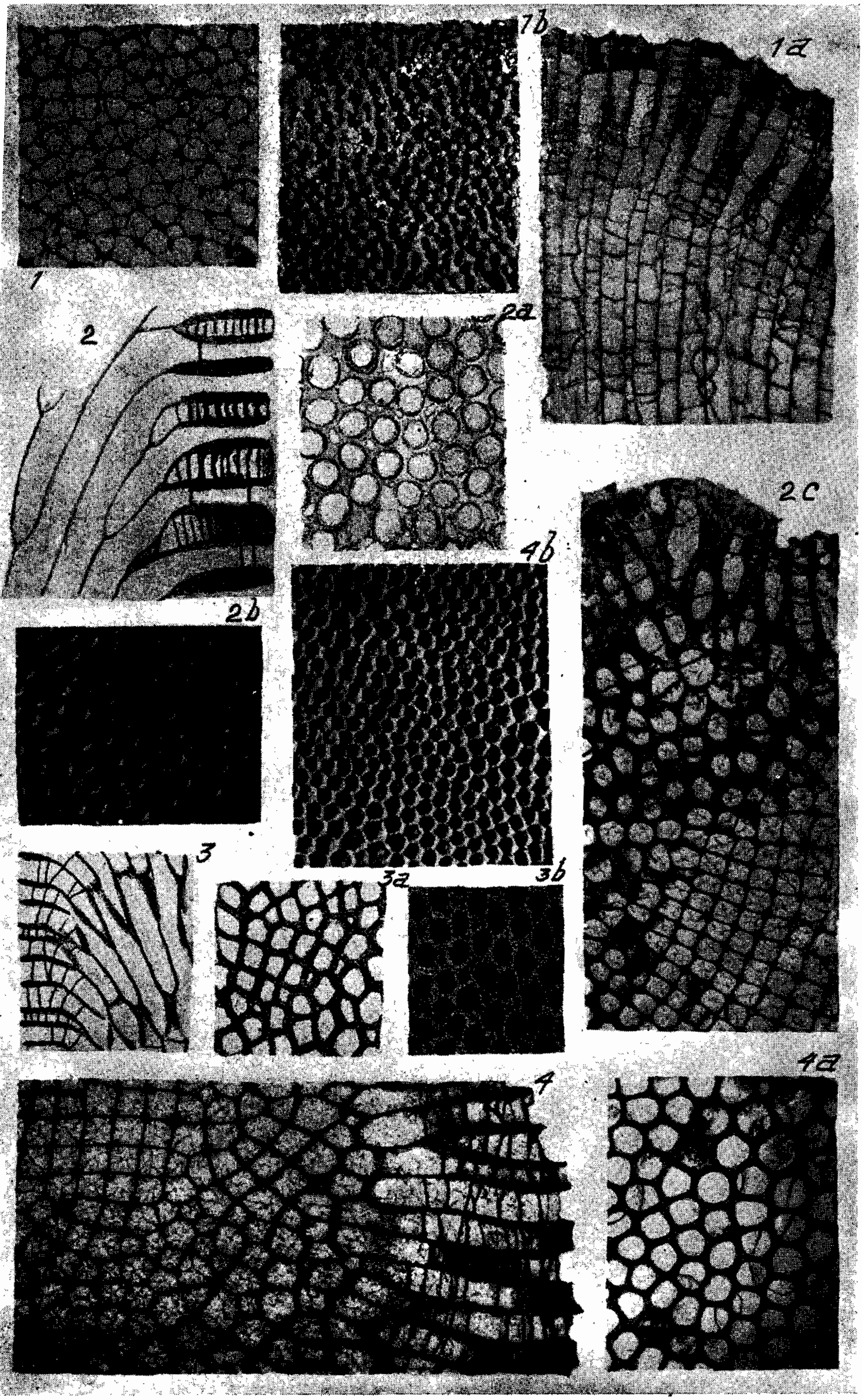

PLATE XXIV.

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Ptilodictya plumaria James.. 874

1. Tangential section of a specimen from the Whitewater division at Richmond, Indiana. x 18.

Stigmatella clavis Ulrich.. 881

2. Tangential section of a specimen from Lawrenceburg, Indiana. x 18.

2a. Vertical section of the same. x 18.

Stigmatella personata Ulrich and Bassler.......................... 884

3. Longitudinal section. x 20. U. and B.*

3a. Tangential section of the same. x 20. U. and B.

3b. Portion of a tangential section. x 50. U. and B.

3c. Tangential section of a specimen from the top of the Richmond formation, on Elkhorn creek, near Richmond, Indiana. x 18.

3d. Longitudinal section of the same. x 18.

Stigmatella crenulata Ulrich and Bassler.......................... 882

4. Longitudinal section of this species. x 20. U. and B.

4a. Tangential section. x 20. U. and B.

4b. Portion of a longitudinal section, showing the structure of the walls that characterizes the genus. x 35. U. and B..

4c. Tangential section of a specimen from the top of the Waynesville formation near Abington, Indiana. x 18.

4d. Longitudinal section of the same specimen. x 18.

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*Figures after Ulrich and Bassler.

Plate XXIV.

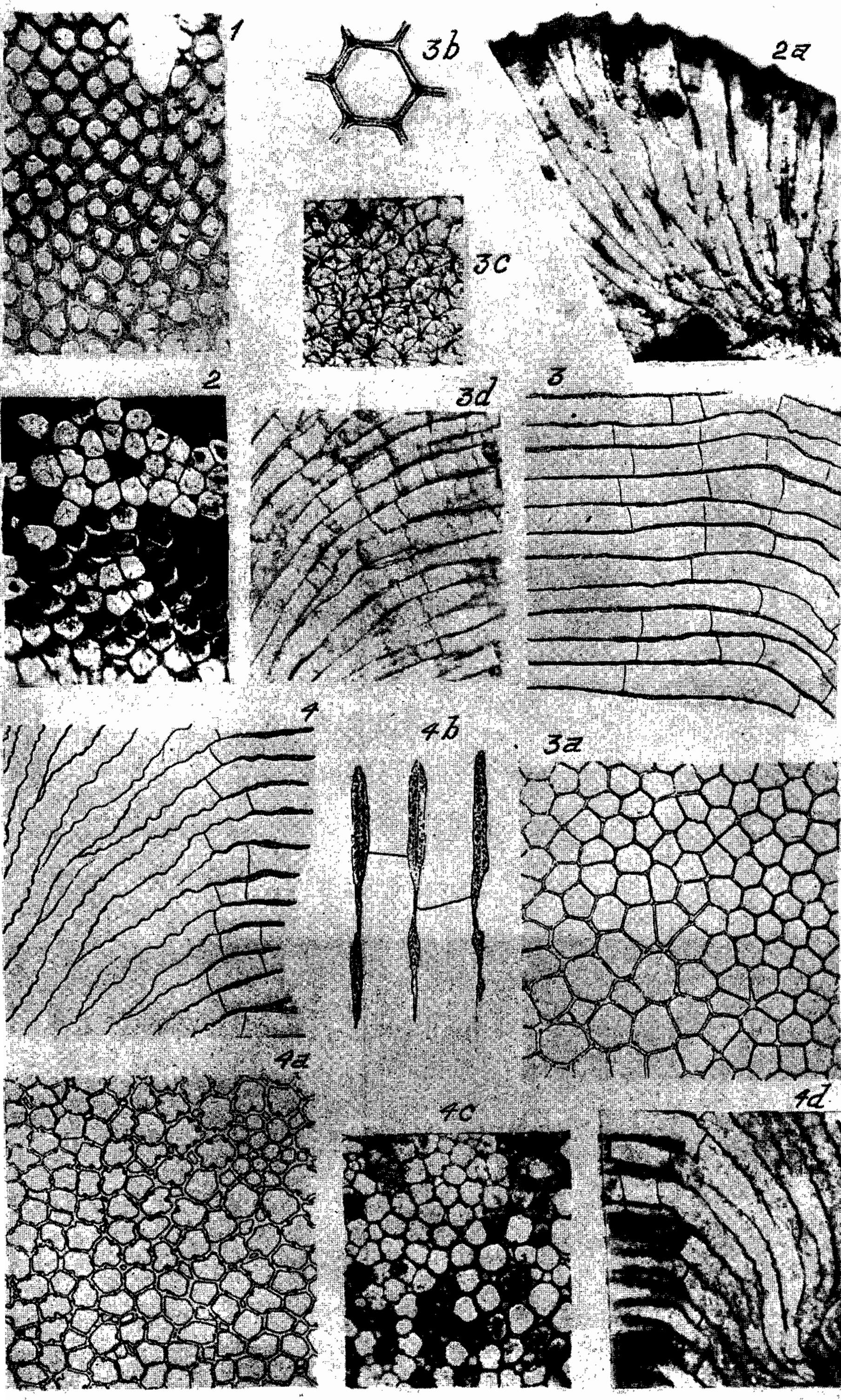

PLATE XXV.

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Stigmatella spinosa Ulrich and Bassler.............................. 884

1. Tangential section. x 20. U. B.

1a. Portion of a tangential section. x 50. U. B.

1b. Longitudinal section. x 20. U. B.

1c. Portion of a longitudinal section. x 50. U. B.

1d. A specimen of this species from the Waynesville formation on Tanner's creek. Tangential section. x 18.

Stigmatella irregularis Ulrich.. 883

2. Longitudinal section of this species. x 20. U. B.

2a. Portion of a tangential section. x 50. U. B.

Stigmatella clavis Ulrich.. 881

3. Portion of a tangential section. x 50. U. B.

Amplexopora sp.. ——

4. Longitudinal section of a specimen from the extreme top of the Liberty formation at Weisburg, Indiana. x 18.

4a. Tangential section of the same. x 18.

4b. Longitudinal section of a specimen from a little lower in the Liberty formation near Weisburg. x 18.

4c. Deep tangential section of a specimen of the same species from Richmond, Indiana. x 18.

Rhombotrypa quadrata Rominger...................................... 877

5. View of a specimen of this species, natural size. From the top of the Waynesville formation on Tanner's creek, Indiana.

Plate XXV.

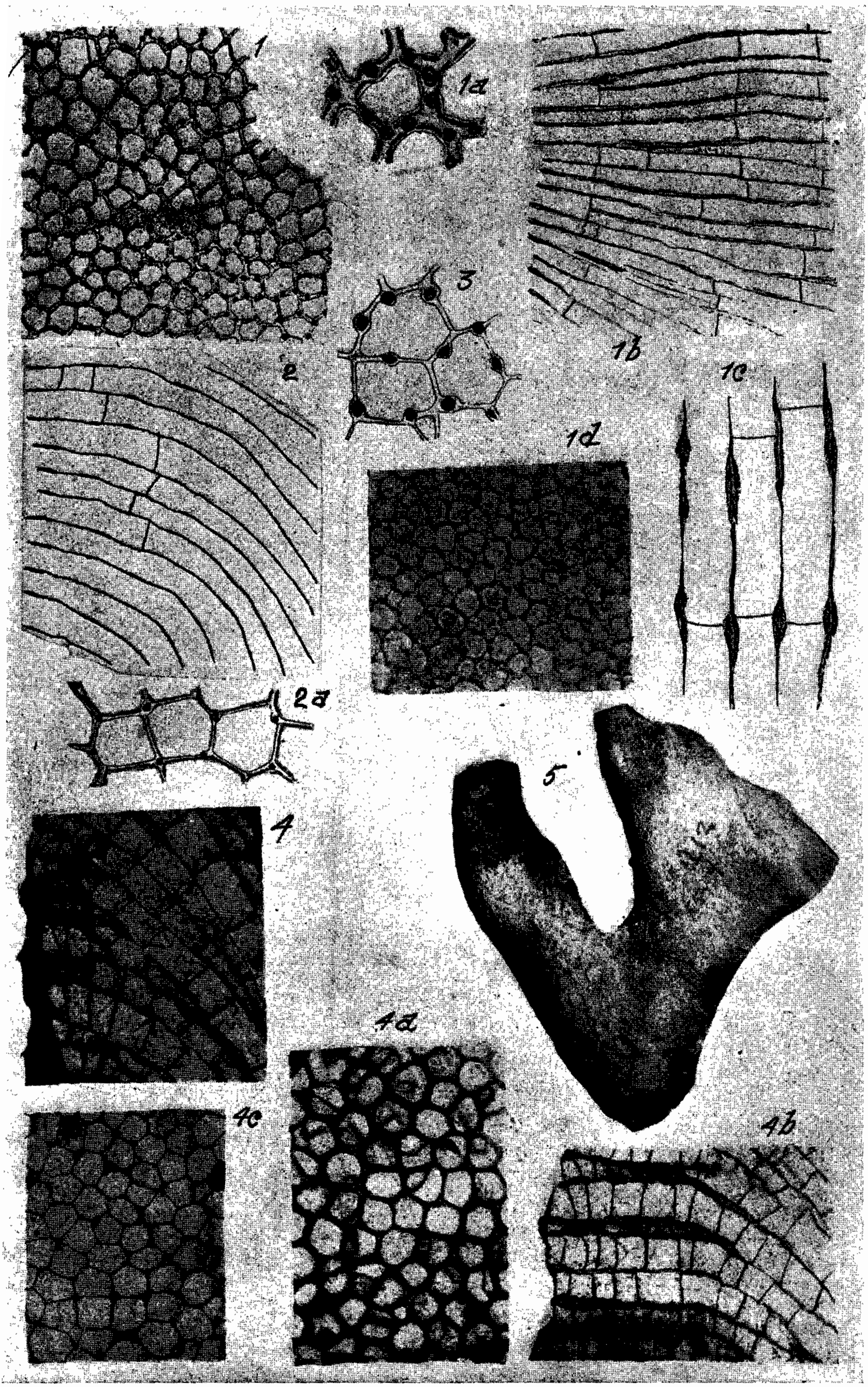

PLATE XXVI.

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Amplexopora pustulosa Ulrich.. 761

1. View of a specimen, natural size. U.

Amplexopora petasiformis Nicholson.. 760

2. View of a typical specimen, natural size. N.

Amplexopora cingulata Ulrich.. 758

3. Specimen from the middle Lorraine at Manchester Station, Indiana.

Amplexopora septosa Ulrich.. 763

4. Specimen from the base of the Lorraine, Vevay, Indiana.

Amplexopora septosa, var. *multispinosa* Cumings.................... 765

5. Specimen from the lower Lorraine or upper Utica near Milton, Indiana.

Atactoporella mundula Ulrich.. 770

6. Large example of this species growing upon the frond of *Dekayia frondosa*, from Lawrenceburg, Indiana.

Atactoporella newportensis Ulrich.. 770

7. Typical specimen of this species. U.

Atactoporella ortoni Nicholson.. 771

11. Portion of the surface of a specimen. x 55.

Arthrostylus tenuis James.. 768

8. Reverse of a spécimen. U.

8a. Celluliferous face, enlarged. U.

8b. Cross section of the stem. U.

8c. A zoarium of this species, natural size. U.

Arthropora shafferi Meek.. 767

9. A fine example of this species from the base of the Liberty formation near Weisburg. x 18.

Arthropora cleavelandi James.. 766

10. A typical example of this species. Cincinnati, Ohio. x 6. B.

Bernicea primitiva Ulrich.. 779

12. Portion of the surface. x 18. U.

Batostoma variabile Ulrich.. 777

13. A specimen of this species, natural size. U.

Batostoma varians James.. 778

14. A specimen from the Richmond formation near Weisburg, Indiana.

Bythopora arctipora Nicholson.. 780

15. Specimen natural size. N.

15a. Specimen from the Utica shales at Guilford, Indiana. x 9.

Plate XXVI.

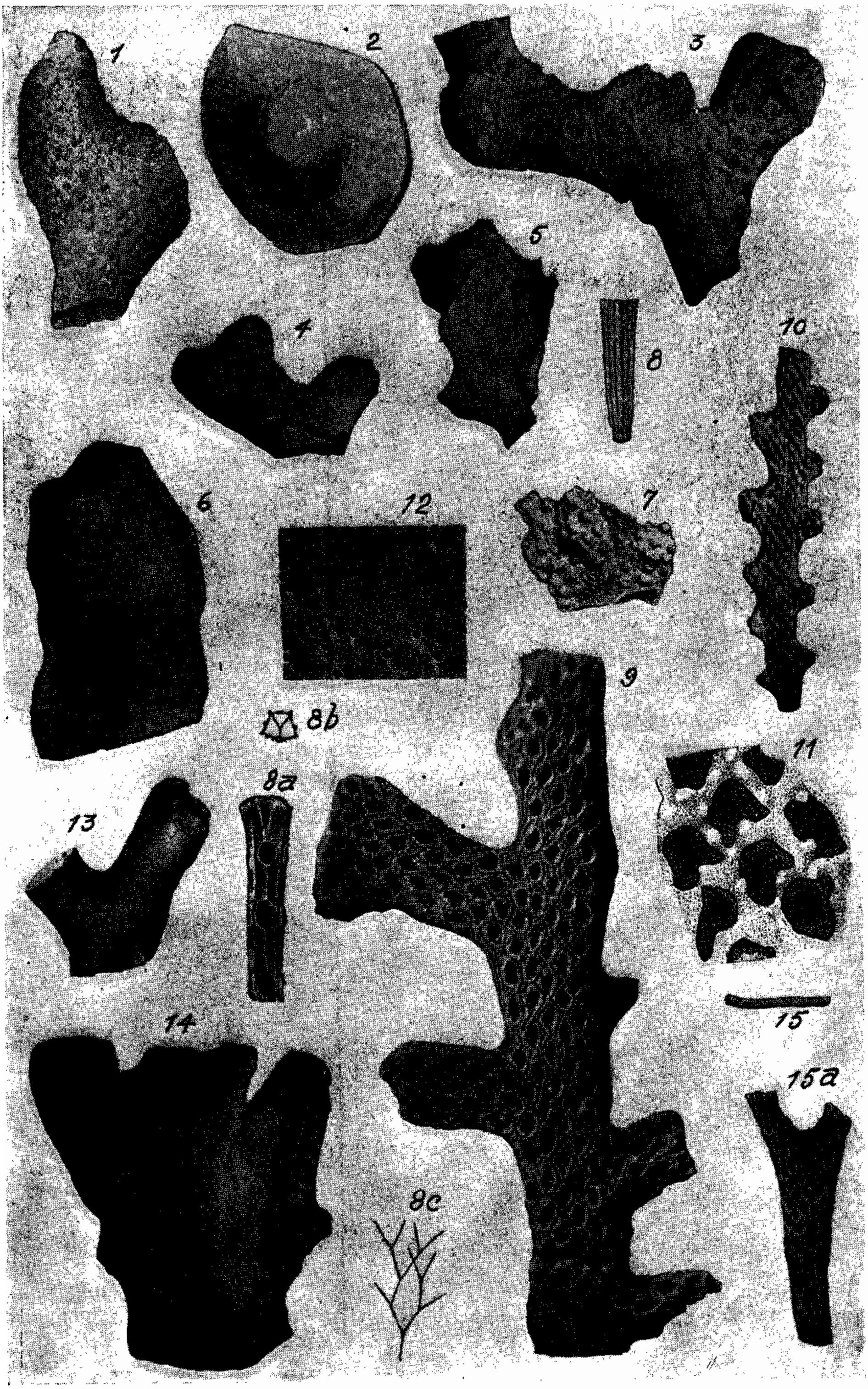

PLATE XXVII.

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Bythopora delicatula Nicholson.. 781

1. Typical specimen of this species. N.

Bythopora gracilis Nicholson.. 782

2 and 2a. Two typical specimens of this species from the upper part of the Lorraine, near Manchester Station, Indiana.

Bythopora parvula James.. 783

3. A specimen from the upper Utica near Guilford, Indiana, apparently belonging to this species. x 9.

Bythopora striata Ulrich.. 784

4. A specimen from the base of the Liberty formation near Weisburg, Indiana, which seems to belong to this species. x 18.

Bythopora meeki James.. 783

5. A rather small example of this common species from near Weisburg. Indiana.

Batostoma jamesi Nicholson.. 775

6. An example of the lobate form of this species. N.

6a. A ramose example from Guilford, Indiana.

Callopora andrewsi Nicholson.. 785

7. A good example of this species from Lawrenceburg, Indiana.

Callopora nodulosa Nicholson.. 786

8. A typical specimen. N.

Callopora onealli James.. 786

9. A specimen from Guilford, Indiana. x 9.

10. A specimen about intermediate in size between typical *C. onealli* and *C. sigillaroides*.

Callopora onealli var. *communis* James.. 788

11. A specimen from the Eden shales at Cincinnati. x 1.5. B.

Callopora dalei Edwards and Haime.. 792

12. Typical example of this species. N.

Callopora ramosa d'Orbigny.. 790

13. Figure of the type in the collection of d'Orbigny. A. P.

13a. Specimen from the Lorraine near Manchester Station, Indiana.

Callopora ramosa var. *rugosa* Edwards and Haime.. 793

14. Typical example of this species. N.

14a. A specimen in which some of the rugae run almost completely around the stem.

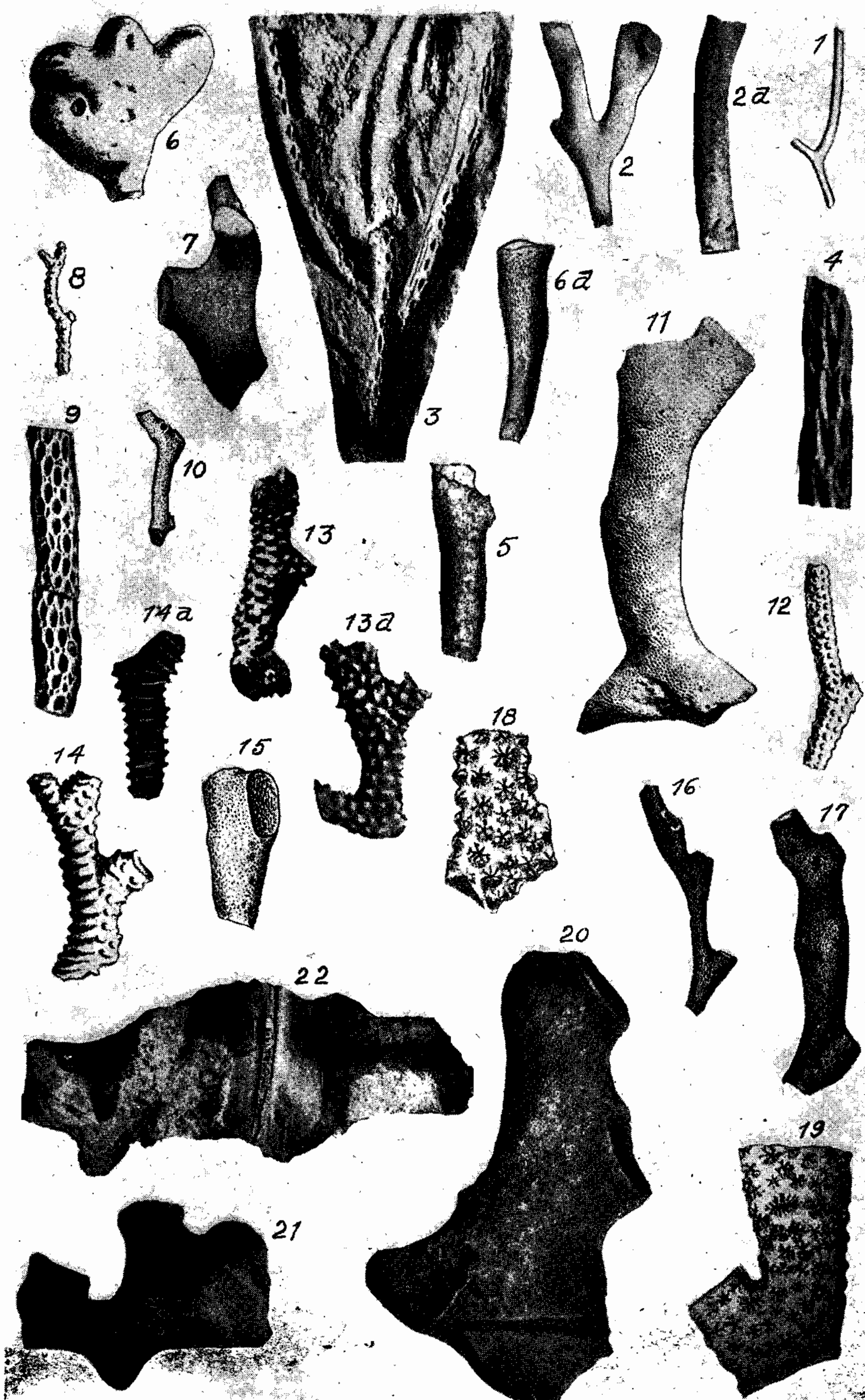
Callopora subplana Ulrich.. 795

15. Specimen from Vevay, Indiana. Lorraine formation.

Coeloclema alternatum James.. 803

16. Typical specimen of this species. U.

Plate XXVII.



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Coeloclema commune Ulrich.. 804

17. Typical example of this species. U.

Constellaria constellata var. *prominens* Ulrich....................... 806

18. A fragment of the natural size. U.

Constellaria constellata Dana.. 804

19. A typical example of this species. U.

Dekayia aspera Edwards and Haime.................................. 810

20. A beautifully preserved specimen of this species in the Redfield collection of the Yale Museum.

Dekayia ulrichi var. *lobata* Cumings................................. 815

21. A subfrondescent example of this variety from the Lorraine at Manchester Station.

Dekayia ulrichi var. *robusta* Foord.................................. 826

22. An irregular and imperfectly preserved specimen of this species from the Lorraine at Manchester Station, Indiana.

PLATE XXVIII.

Plate XXVIII.

PLATE XXIX.

Plate XXIX.

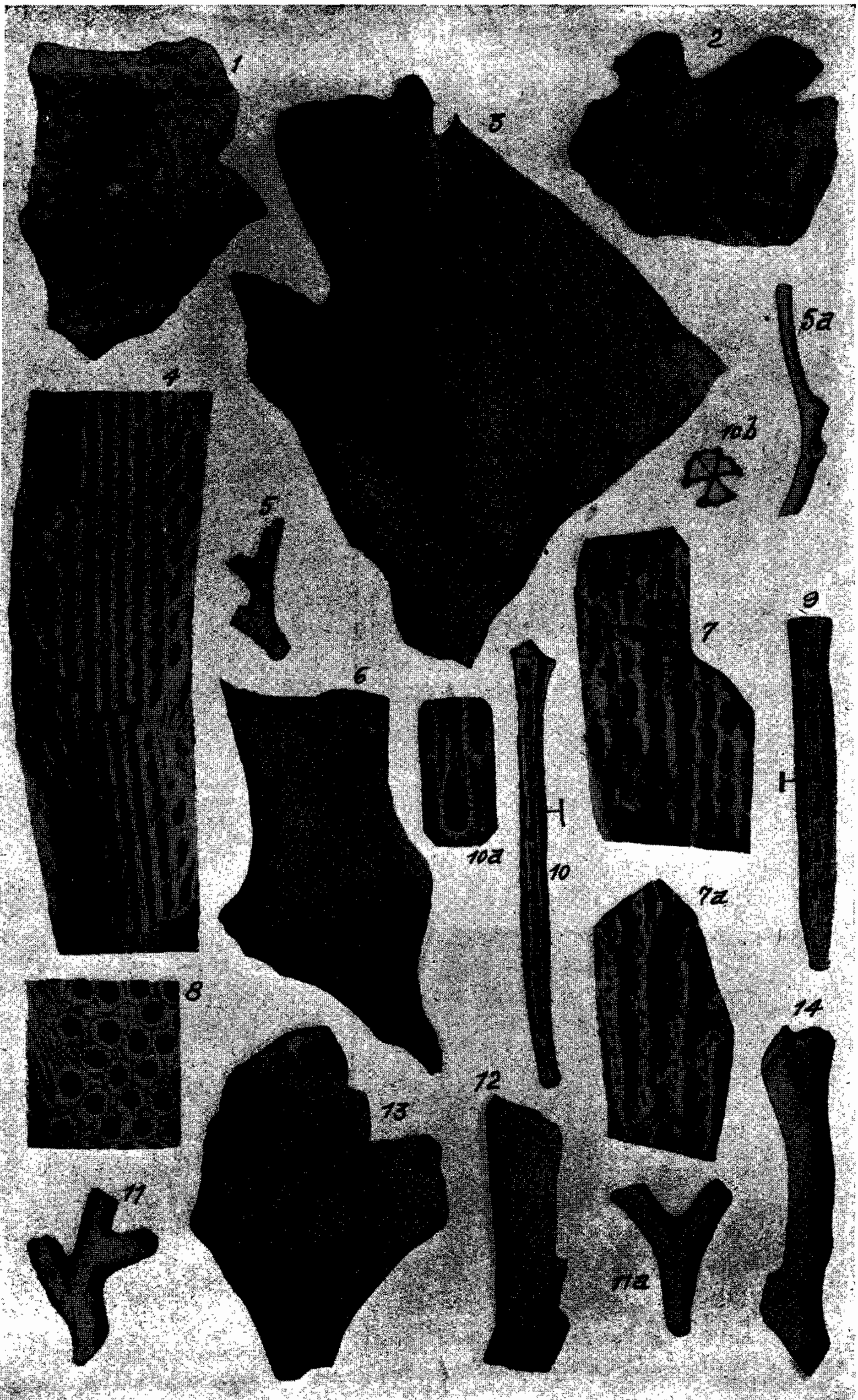

PLATE XXX.

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Homotrypa dawsoni Nicholson.................................... 842

1. A large and beautifully preserved specimen of this species from Brookville, Indiana.

Homotrypa flabellaris Ulrich.. 845

2. A typical example of this species from the base of the Liberty formation near Weisburg, Indiana. The photograph fails to show the very low and inconspicuous monticules.

Homotrypa flabellaris var. *frondosa* Cumings....................... 846

3. A fine specimen of this variety from the Arnheim formation near Harmon's Station, Indiana. This is the type of the variety.

Homotrypa nicklesi Bassler... 847

4. Typical example of this species. B.

Homotrypa nitida Bassler... 848

5 and 5a. Two examples of the typical form of this species. B.

Homotrypa obliqua Ulrich.. 848

6. A specimen of this species from the Lorraine at Lawrenceburg, Indiana.

Homotrypa curvata var. *praecipta* Bassler.......................... 841

7. A specimen of this variety from the base of the Lorraine at Manchester Station, Indiana.

7a. A view of one of the types. B.

Homotrypa ramulosa Bassler... 849

8. A view of the type. B.

Homotrypa wortheni James.. 849

9. View of a specimen from Richmond, Indiana. B.

Homotrypa wortheni var. *prominens* Bassler.......................... 851

10. View of a typical example. B.

Homotrypella cf. *rustica* Ulrich...................................... 851

11. View of a specimen of this species from the Whitewater division at Richmond, Indiana.

Monticulipora epidermata Ulrich and Bassler........................ 857

12. View of a medium sized example of this abundant species from the Whitewater division at Richmond, Indiana.

Plate XXX.

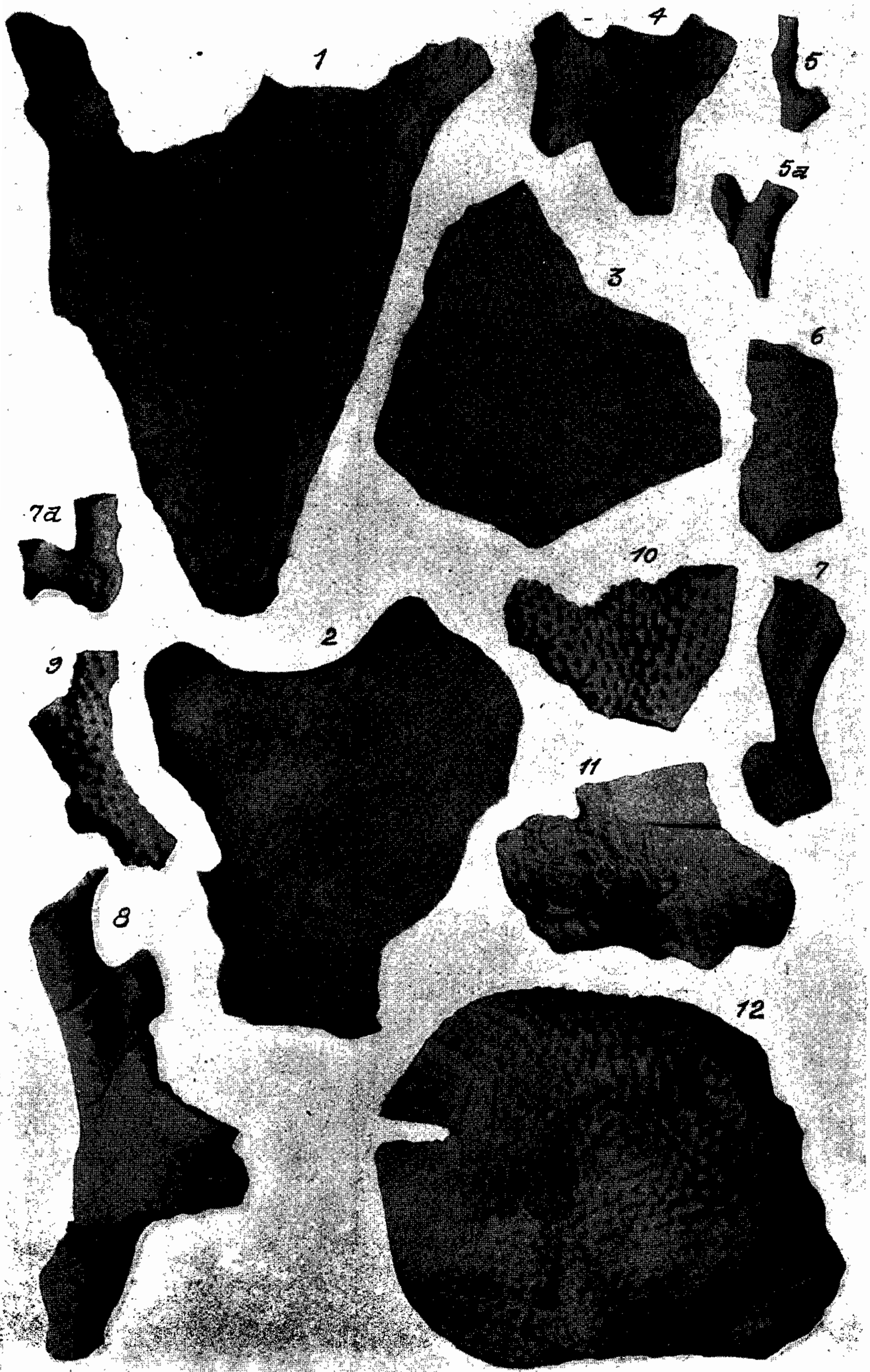

PLATE XXXI.

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Monticulipora mammulata d'Orbigny 859

1. From a photograph of the type in the collection of d'Orbigny. A. P.

1a. A specimen of the more massive form of the species from the Lorraine at Lawrenceburg, Indiana.

Monticulipora parasitica Ulrich 862

2. A specimen of this species growing on a specimen of *Streptelasma rusticum.* From the base of the Liberty formation near Weisburg, Indiana.

Nicholsonella vaupeli Ulrich 863

3. A finely preserved specimen of this species from the Lorraine at Vevay, Indiana.

Peronopora pavonia d'Orbigny 866

4. Photograph of the type in the collection of d'Orbigny. A. P.

4a. A large and very beautiful specimen from Brookville, Indiana, in which the maculae are elevated very slightly into low monticules.

Peronopora vera Nickles 867

5. A fragment of the zoarium of this species from near Rising Sun, Indiana.

Prasopora hospitalis Nicholson 871

6. A small but typical specimen of this common species from the base of the Liberty formation near Weisburg, Indiana.

Rhopalonaria venosa Ulrich 879

7. A specimen from Weisburg, Indiana. x 2.

7a. A portion of the type. x 3. U.

Plate XXXI.

PLATE XXXII.

Page

Stomatopora inflata Hall.. 886

1. View of a typical specimen enlarged. The natural size shown below in the small figure. N.

1a. Several zooecia still further enlarged. N.

Stomatopora arachnoidea Hall.................................. 885

2. Portion of a zoarium considerably enlarged to show the form of the zooecia. N.

2a. A zoarium growing on the stem of a species of Trepostomata. Natural size. N.

2b. The same enlarged. N.

2c. A specimen from the Eden shale at Guilford, Indiana, apparently belonging to this species, though more slender and with wider spacing of the zooecia than shown in Nicholson's figures. x 9.

Proboscina frondosa Nicholson.................................. 873

3. Portion of a zoarium, enlarged. N.

3a. Small portion of a zoarium, still further enlarged to show the shape of the zooecia. N.

3b. Small portion of a zoarium of this species (?) from Guilford, Indiana. x 9.

Proboscina auloporoides Nicholson................................ 872

4. Portion of a zoarium enlarged. N.

4a. Small portion of a zoarium still further enlarged to show the form of the zooecia. N.

5. A few branches of this species associated with a *Stomatopora*. Versailles, Indiana. x 9.

Ptilodictya plumaria James...................................... 874

6. Basal portion of a frond of this species. U.

Rhinidictya lata Ulrich.. 875

7. Part of a zoarium, natural size. U.

7a. Portion of the surface. x 18. U.

Rhinidictya parallela James...................................... 875

8. View of the type. x 6. B.

Spatiopora maculosa Ulrich...................................... 879

9. Portion of the surface of the type, showing one of the maculae of larger zooecia. x 18. U.

Spatiopora tuberculata Edwards and Haime........................ 880

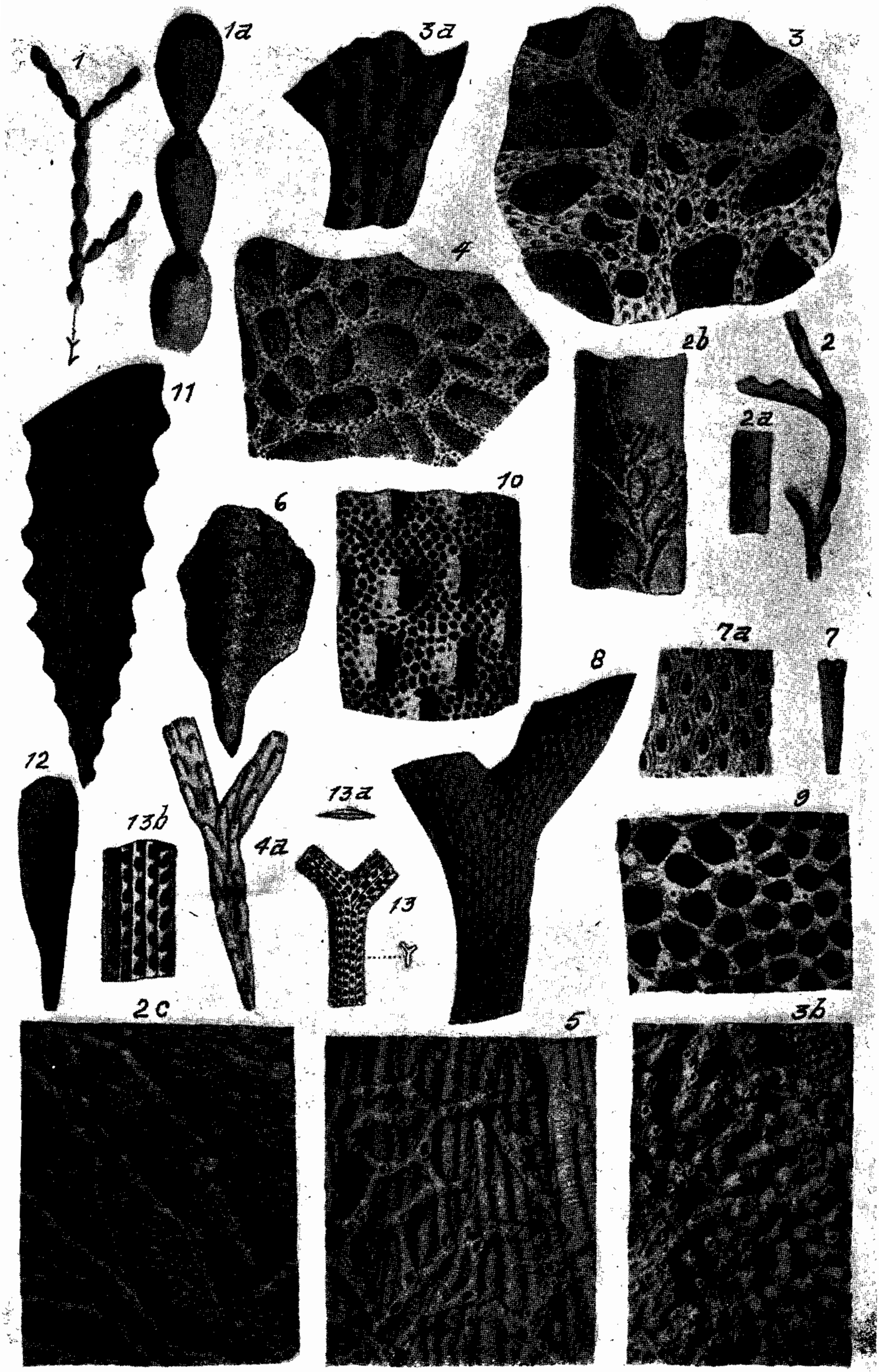
10. Portion of the surface of the type enlarged. E. and H.*

Cornulites flexuosa Hall 1067

11. A specimen referred to this species from the base of the Lorraine formation near Manchester Station, Indiana. x 18.

*Figure after Edwards and Haime.

Plate XXXII.



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Cornulites sp. . . . . ——

12. A specimen of a species common on *Dekayia frondosa* and other Bryozoa.

Dicranopora emacerata Nicholson 827

13. A specimen of this species enlarged. Natural size shown in small figure to right. N.

13a. Cross section of stem enlarged. N.

13b. Portion of branch still further enlarged. N.

PLATE XXXIII.

Page

Catazyga headi Billings.. 896

1. Ventral view. M.
1a. Dorsal view. M.
1b. Profile view. M.
1c. Anterior view. M.

Crania laelia Hall.. 897

2. Several specimens of this species on the shell of a Strophomena. M.

Crania scabiosa Hall.. 898

3. A group of examples of this species on the shell of Rafinesquina alternata. M.

3a. Specimen from the Waynesville formation at Versailles, Indiana, showing several examples of this species on the shell of Rafinesquina.

Dalmanella testudinaria var. *multisecta* Meek...................... 901

4. Ventral valve of a specimen from the upper Eden shales at Guilford, Indiana.

4a. Dorsal view of a specimen from the same locality.
4b. Interior of the dorsal valve.
4c. Interior of the ventral valve.

Dalmanella testudinaria var. *emacerata* Hall........................ 898

5. Dorsal valve. H. and C.
5a. Interior of the dorsal valve enlarged. H. and C.

Dalmanella testudinaria var. *meeki* Miller.......................... 899

6. Interior of the dorsal valve of a specimen of this species from Minnesota. H. and C.

6a. Interior of the ventral valve. M.
6b. Interior of the dorsal valve. M.

6c-6f. Various views of a number of examples of this species from Madison, Indiana.

6g. View of a portion of a slab from Versailles, Indiana, showing the great abundance of this species in the Waynesville formation.

Dinorthis retrorsa Salter.. 902

7. Ventral view of a very perfect specimen. M.
7a. Dorsal view. M.
7b. Profile view. M.
7c. Interior of the ventral valve of a large individual. M.
7d. Portion of the surface enlarged. M.

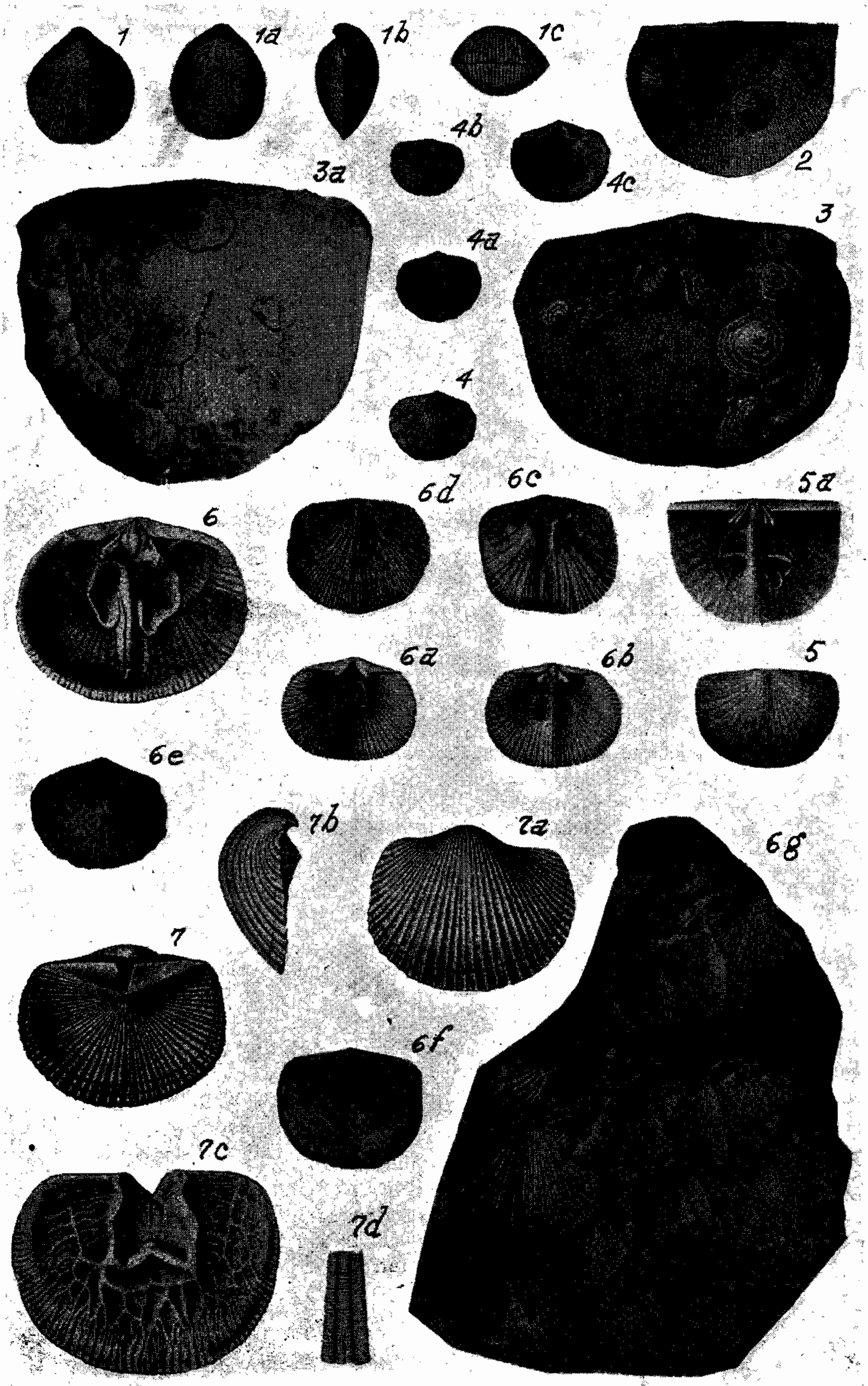
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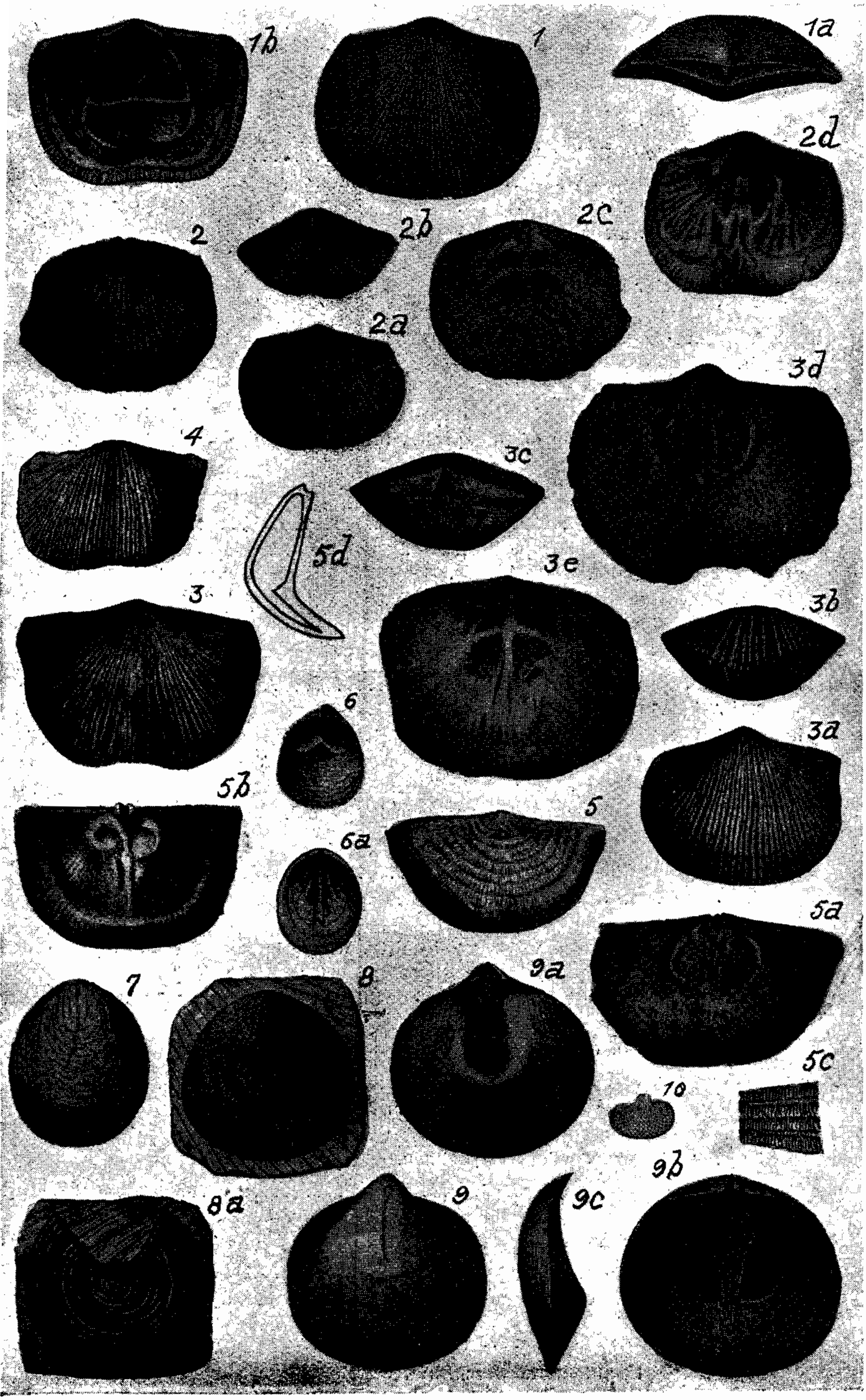
PLATE XXXIV.

Plate XXXIV.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8
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PLATE XXXV.

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Platystrophia lynx Eichwald.................................... 914

1. A specimen of the normal type from the middle part of the Lorraine at Vevay, Indiana.

1a. A somewhat more gibbous specimen from the same locality, anterior view.

1b. Posterior view of the same.

1c. Profile view of a similar specimen.

1d. Interior of the ventral valve, showing the deeply impressed muscular pit.

1e. Interior of the dorsal valve.

1f. Outline drawing of a specimen from the "Lynx" beds of Cincinnati. This is the gerontic form of the species, found in the top of the Lorraine, at Cincinnati.

1g. Ventral view of the same.

Platystrophia lynx var. *laticosta* Meek.............................. 918

2. Ventral view of a specimen from the base of the Liberty formation at Versailles, Indiana.

2a. Dorsal view of a similar specimen.

2b. Ventral view of a larger and somewhat more acuminate specimen from the same locality.

Platystrophia acutilirata Conrad.................................. 912

3. A specimen of this species from Weisburg, Indiana, intermediate in form between *P. laticosta* and the typical *P. acutilirata*.

3a. A similar, though somewhat larger form from Versailles, Indiana.

3b. A more extended form from Richmond, Indiana.

3c. A very much extended form from Richmond.

3d. A similar form from Versailles, Indiana.

Platystrophia acutilirata var. *senex*................................ 913

4. A specimen of this form from the Whitewater division at Richmond, Indiana.

4a. A specimen from the same locality, which is still shorter on the hinge-line.

4b. Profile of another specimen showing the extreme incurvature of the beaks, and the exceptional gibbosity.

4c. A section of the same to show the great thickening of the shell.

Platystrophia lynx var. *moritura*................................ 920

5. Ventral view of a specimen from Elkhorn creek, near Richmond, Indiana.

5a. Dorsal view of a larger specimen.

Platystrophia costata Pander....................................... 914

6. Ventral view of a specimen of this species from Cincinnati, Ohio.

6a. Anterior view of the same specimen.

Platystrophia lynx (nepionic stage)............................. 914

7. Dorsal view of a young specimen 1 mm. in breadth, from Vevay, Indiana. x 22.

7a. Ventral view of same. x 22.

7b and 7c. Profile of the dorsal and ventral valves respectively. x 22

Plate XXXV.

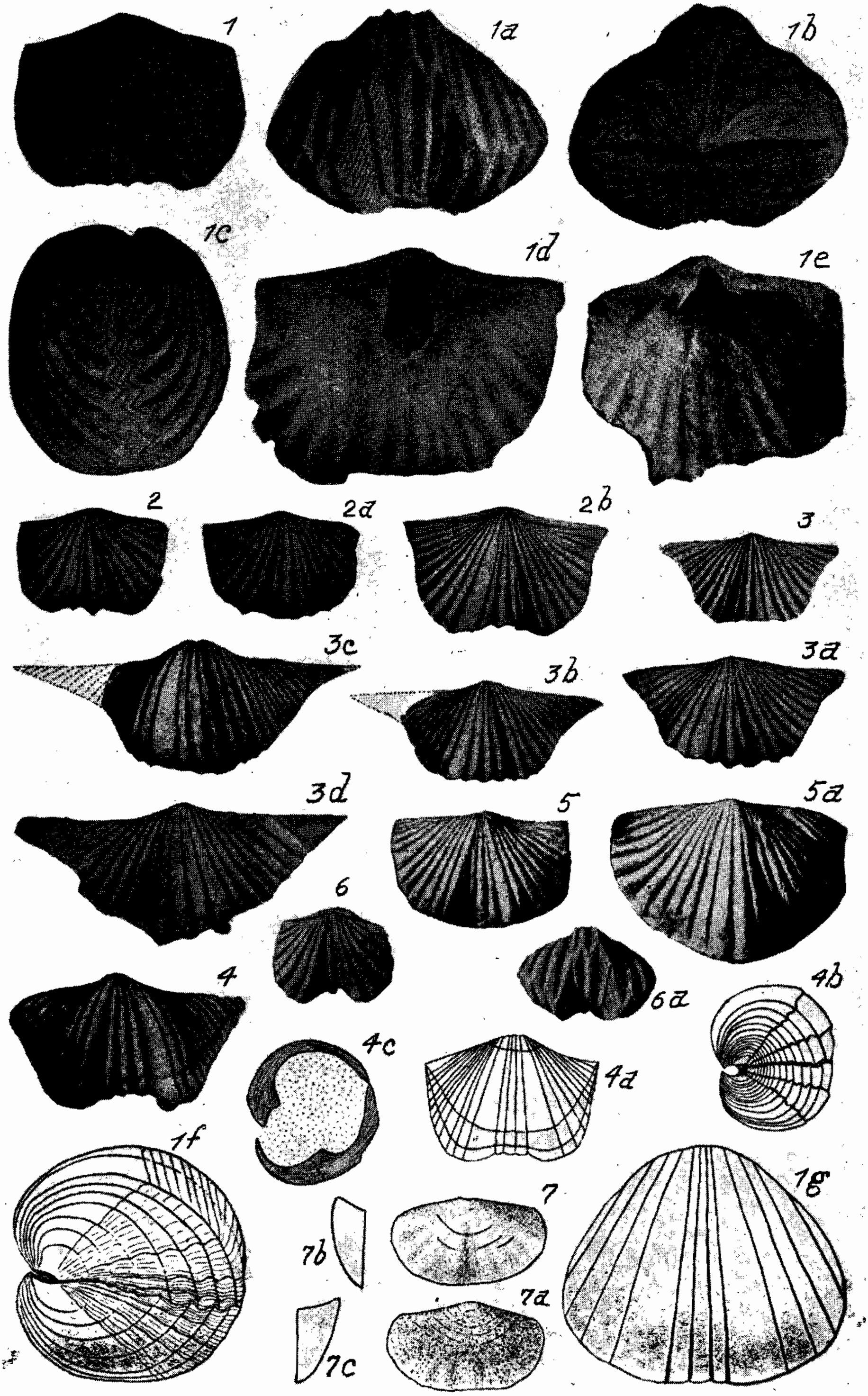
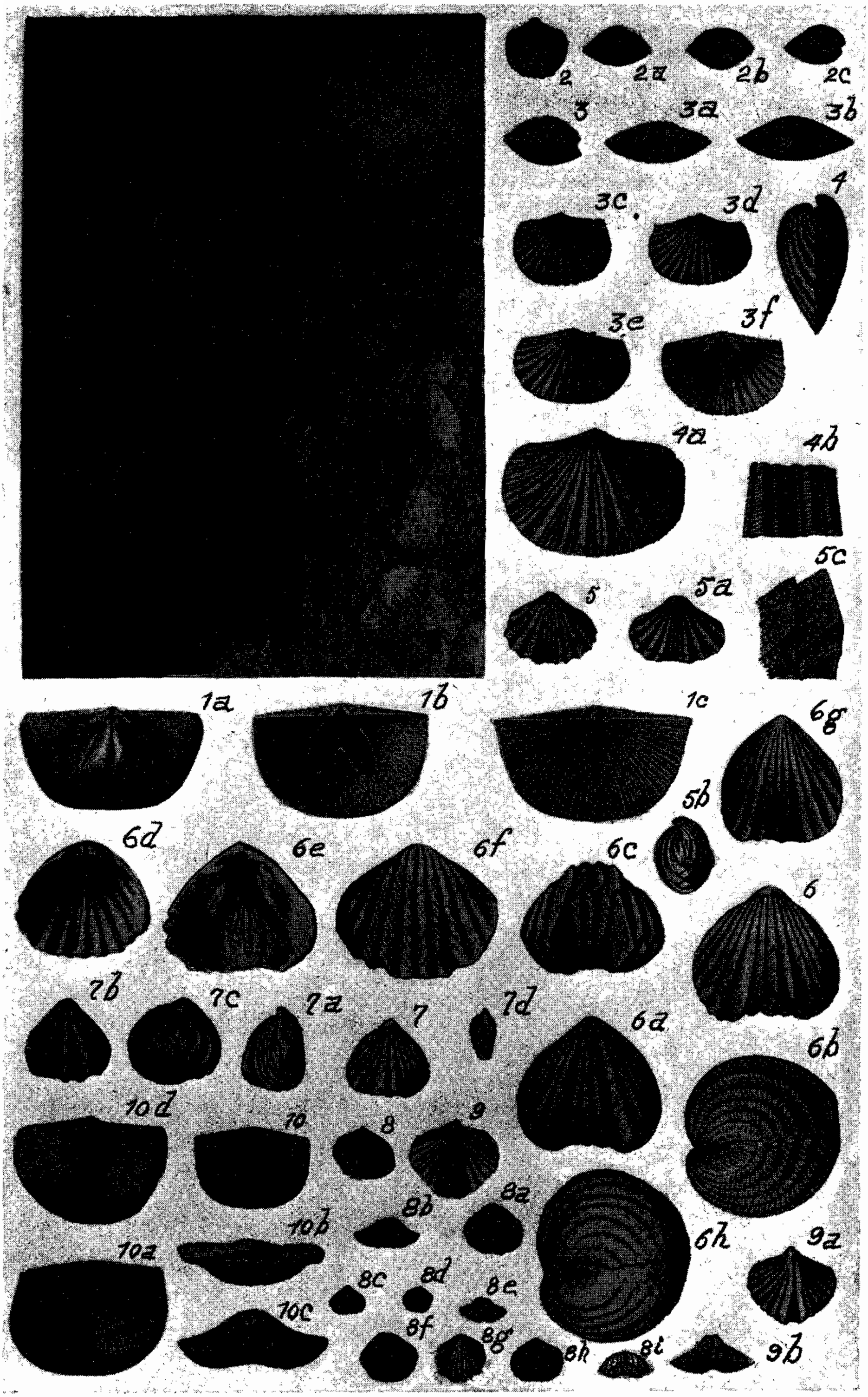


PLATE XXXVI.

Plate XXXVI.



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8-8b. Ventral, dorsal and anterior views of a number of specimens of the normal size from Lawrenceburg, Indiana.

8c-8d. Dorsal and ventral views of two small specimens. Same locality.

8e, 8f and 8h. Posterior, ventral and dorsal views of other specimens from the same locality.

8g. Ventral view. M.

8i. Anterior view. M.

9-9b. Dorsal, ventral and anterior views of this species. M.

10. Dorsal view of a rather small specimen. M.

10a. Ventral view of a larger individual. M.

10b. Posterior view. M.

10c. Anterior view. M.

10d. Ventral view of a specimen from the Whitewater division at Richmond, Indiana.

PLATE XXXVII.

Page

Rafinesquina alternata Emmons.................................... 926

1. Dorsal view of a rather narrow specimen, resembling exactly in outline the var. *fracta*, but with much more massive shell. Weisburg, from the Liberty formation.

1a. Ventral view of a very large, flat form from the lower Richmond at Versailles, Indiana.

1b. View of the type specimen figured by Emmons. E.*

1c. Interior of the ventral valve of the normal form of the species. M.

1d. Profile of a very thin specimen from the lower Richmond at Versailles, Indiana.

1e. Portion of the surface of No. 1a enlarged.

Rafinesquina alternata var. *loxorhytis?*............................ 928

2. Dorsal view of a specimen from Weisburg, Indiana (base of the Liberty formation) that has the general form of this variety.

2a. Profile of a similar specimen from Versailles, Indiana.

Rafinesquina alternata var. *ponderosa*.............................. 929

3. Dorsal view of a specimen from the Lorraine at Lawrenceburg, Indiana.

3a. Interior of the dorsal valve of a similar specimen from the same place.

Rafinesquina alternata var. *nasuta* Conrad.......................... 928

4. Ventral view of an example of this variety. M.

Rafinesquina alternata var. *fracta* Meek............................ 927

5. Dorsal view of a large specimen. M.

5a. Section of the two valves showing the depressed form. M.

*Figure after Emmons.

Plate XXXVII.

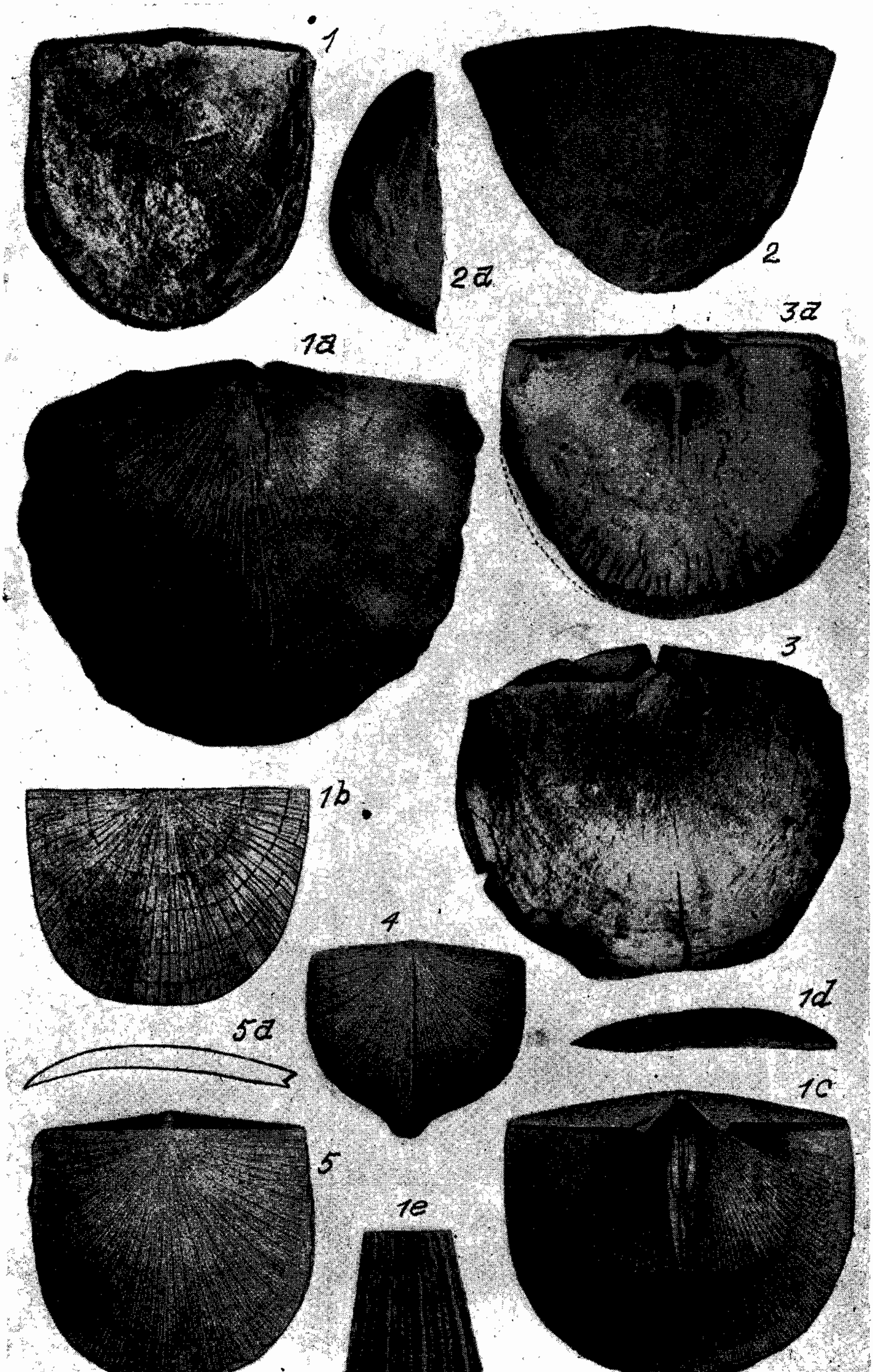

PLATE XXXVIII.

Page

Strophomena neglecta James? 934

1. Interior of the dorsal valve. M.

1a. Interior of the ventral valve. M.

1b. Dorsal valve. M.

Strophomena sinuata Meek 941

2-2c. Posterior, anterior, dorsal and ventral views of this species. M.

2d. Interior of the ventral valve. M.

2e. Interior of the dorsal valve. M.

Strophomena planoconvexa Hall 938

3-3b. Dorsal, ventral and posterior views of this species. M.

3c. Interior of the ventral valve. M.

3d. Interior of the dorsal valve. M.

3e. Section through the two valves. M.

Strophomena planumbona Hall 939

4. Dorsal view of this species. M.

4a. Interior of the ventral valve. M.

4b. Interior of the dorsal valve. M.

4c. Section of the two valves. M.

4d. Portion of the surface enlarged. M.

Strophomena nutans Meek 936

5. Ventral view. M.

5a. Interior of the ventral valve. M.

5b. Section of the two valves. M.

5c. Portion of the surface enlarged. M.

Strophomena planumbona var. *subtenta* Hall 940

6. Ventral view of this species. M.

6a. Interior of the ventral valve. M.

6b. Interior of a ventral valve of this variety (?) from Weisburg, Indiana.

6c. Dorsal view of another specimen from the same place.

6d. Section of the two valves. M.

6e. Portion of the surface enlarged. M.

6f. Dorsal view of another specimen.

6g. Posterior view. M.

Plate XXXVIII.

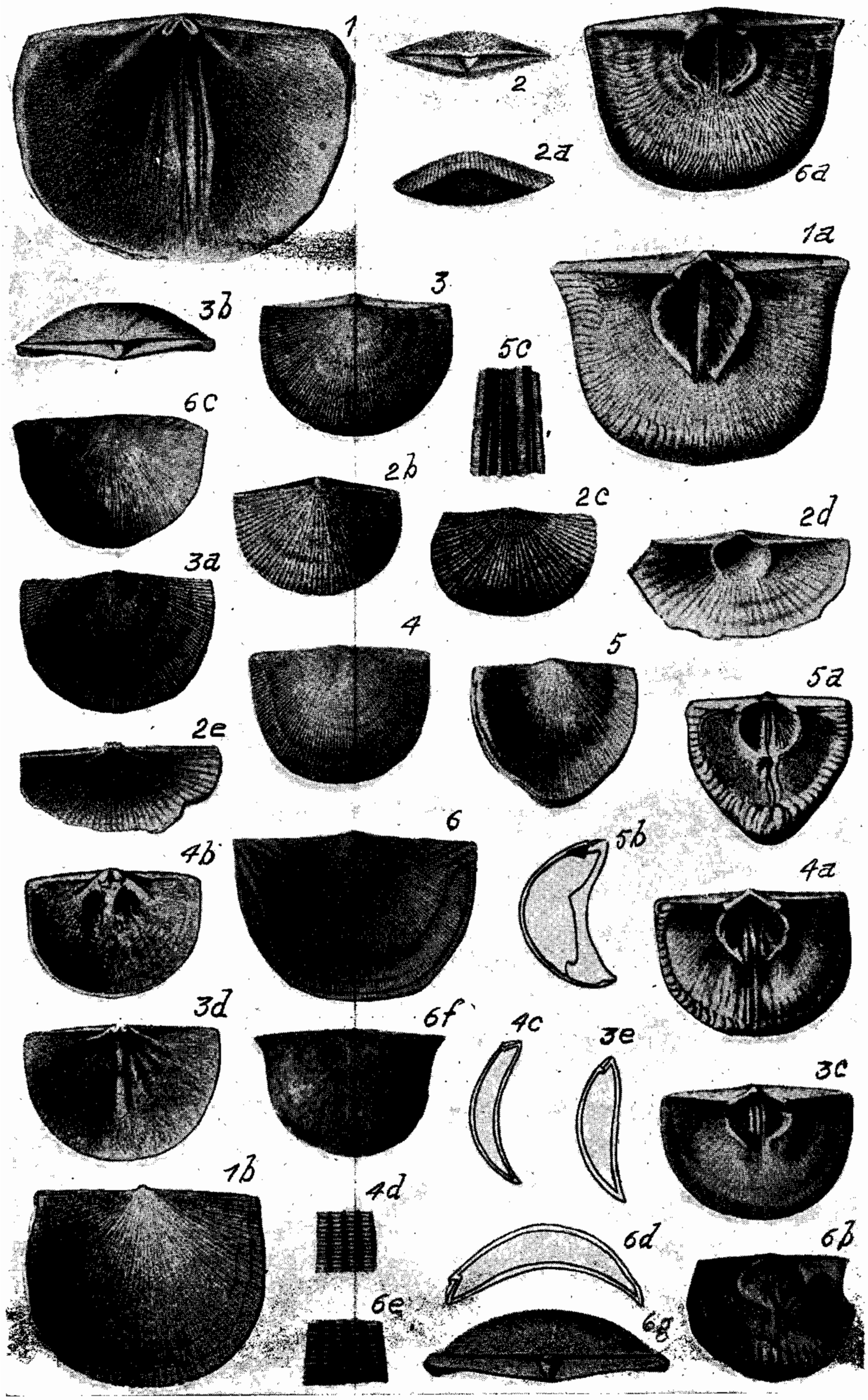

PLATE XXXIX.

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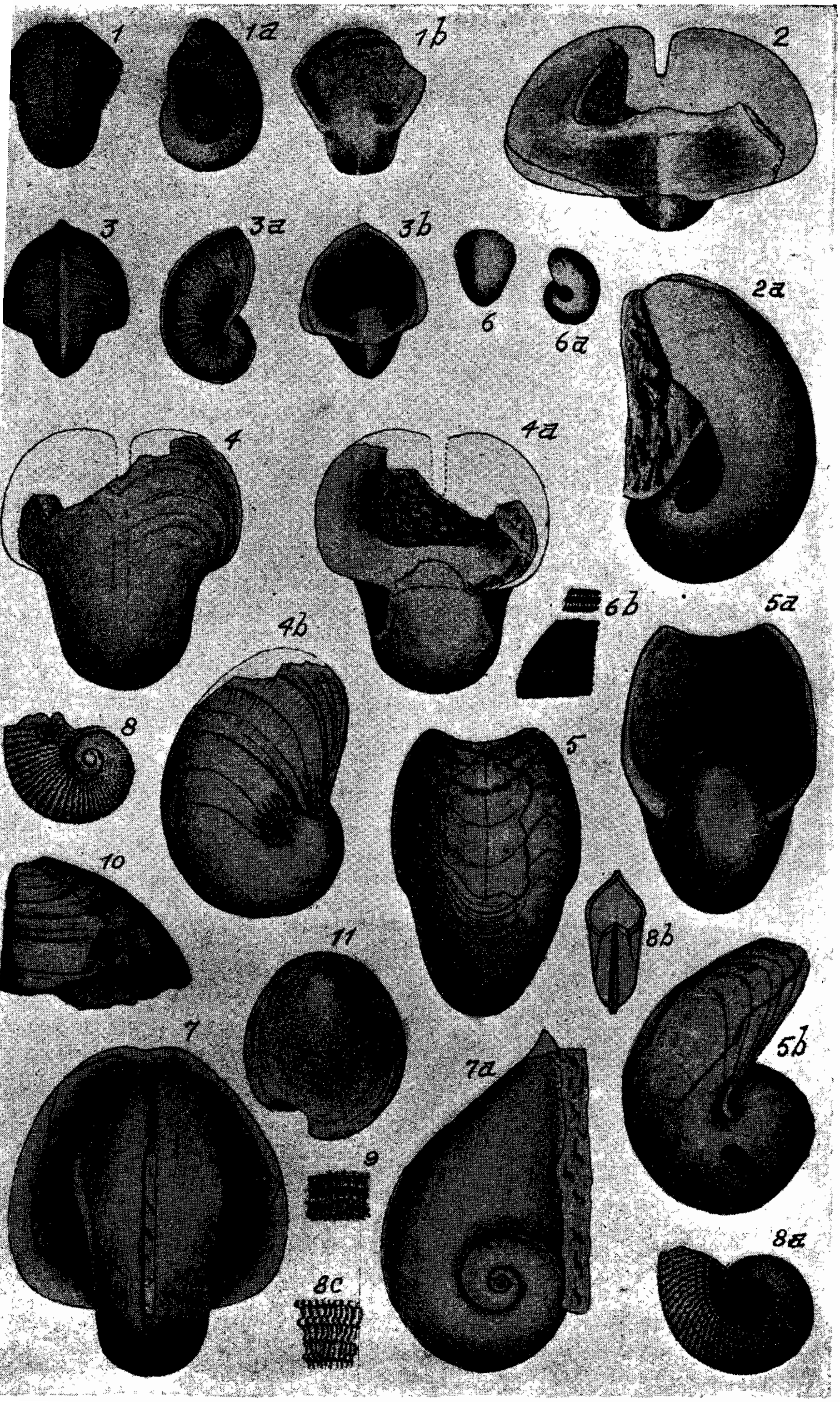

PLATE XL.

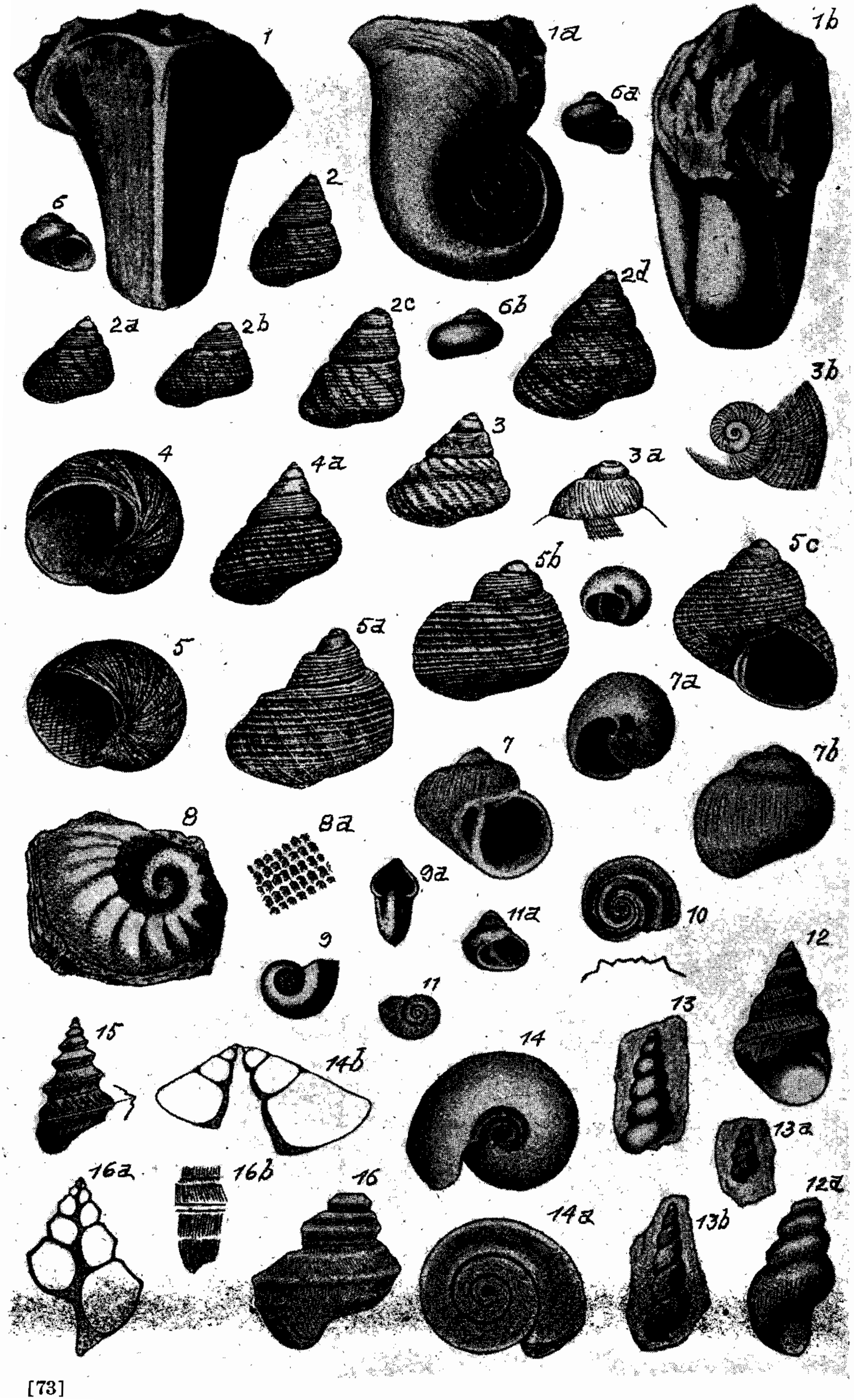
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PLATE XLI.

Page

Lophospira ampla Ulrich 966

1 and 1b. Apertural and dorsal views of a large specimen from the Lorraine formation, Newport, Ky. U.

1a. Apertural view of a large specimen from the Richmond formation, Boyle county, Kentucky. U.

Lophospira tropidophora Meek 969

2. A specimen of the usual form from the Lorraine group, Newport. Ky. U.

2a. A form from the Richmond group at Madison, Indiana. U.

2b. Portion of the last whorl of a smaller example from the Richmond formation, Butler county, Ohio. U. x 2.

2c and 2d. Two views of the form to which Miller gave the name *multigruma*. Miller.

Lophospira hammeli Miller 969

3 and 3a. Apertural and dorsal views of this species. Miller.

Lophospira bowdeni Safford .... *

4. A large specimen, imperfect at both ends, from the Richmond formation, Boyle county, Kentucky. U.

4a. Last whorl and aperture of another specimen from the same locality. U.

4b. A narrow, elongate specimen from the same locality. U.

Oxydiscus magnus Miller 970

5. Side view of the type. Miller.

Raphistoma richmondense Ulrich 972

6 and 6a. Two views of a specimen from Richmond, Indiana, retaining some of the shell. U.

6b. Portion of the surface of the last part of the whorl of same. x4. U

Schizolopha moorei Ulrich 975

7. View of a nearly perfect cast from Richmond, Indiana. U.

7a. Vertical section of an unusually high example of the Cincinnati form. U.

7b. Gutta-percha impression from a natural mold of a Richmond specimen. U.

7c. Basal view of No. 7. U.

Clathrospira subconica Hall 956

8. Cast of a specimen from Minneapolis, Minn. U.

8a and 8b. Two views of a cast from the Stone's River group at Beloit, Wis. U.

*Safford gave no description of this species. For an excellent description see Geol. Nat. Hist. Surv., Minnesota, vol. III, pt. II, p. 986.

Plate XLI.

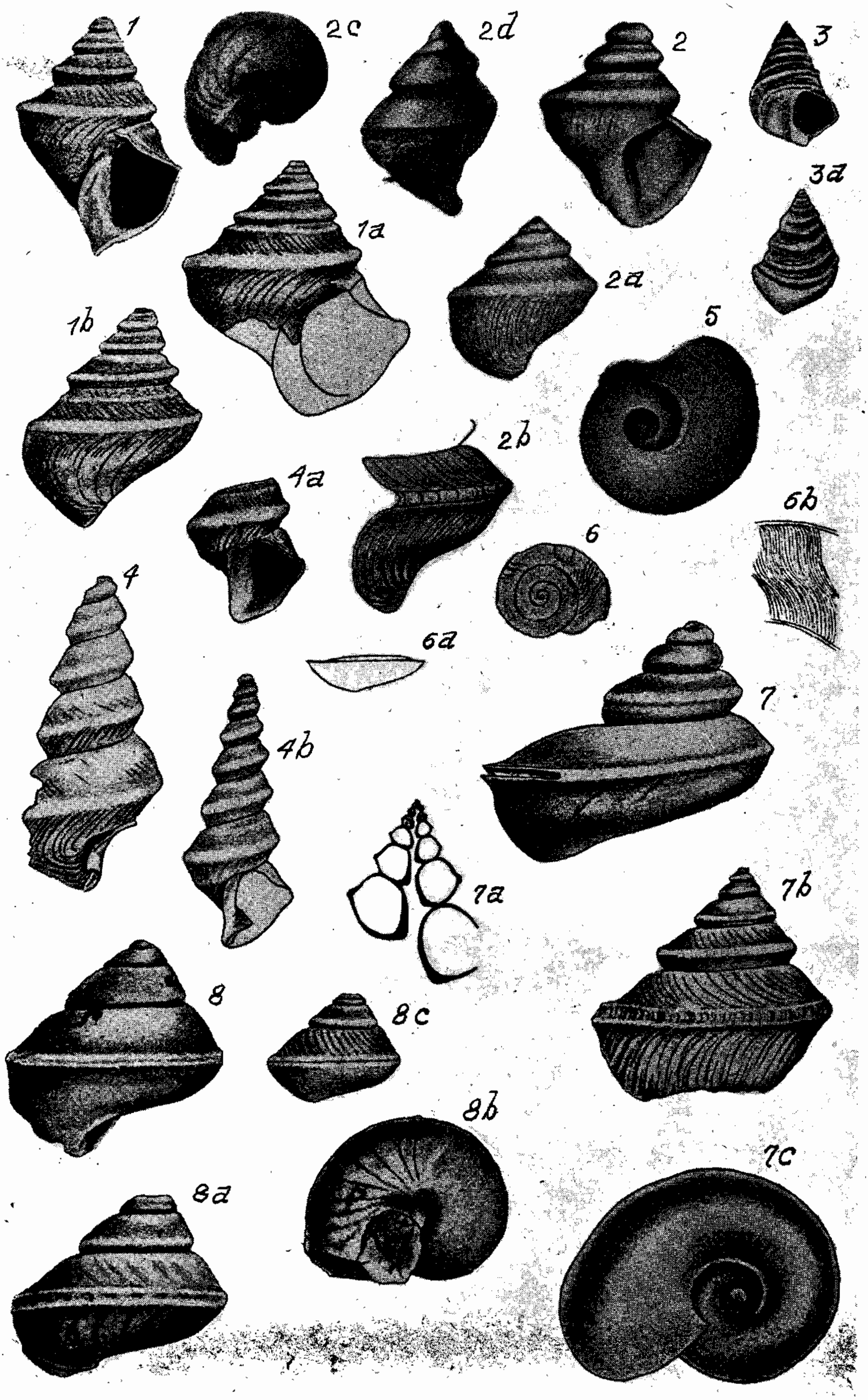

PLATE XLII.

Page

Trochonema madisonense Ulrich.. 976

1-1b. Three views of the type of this species. U.

Conularia formosa Miller and Dyer.. 958

2. View of the type. M. and D.*

Hyolithes (?) *dubious* Miller and Faber.. 964

3. View of the type. M. and F.**

Hyolithes versaillesensis Miller and Faber.. 965

4 and 4a. Several views of the type. M. and F.

Cornulites richmondensis Miller.. 1065

5. View of the type. x 1½. Miller.

Anomalodonta costata Meek.. 987

6 and 6a. Two views of the type. M.

Byssonychia alveolata Ulrich.. 989

7-7a. Two views of a right valve of this species. In one view the left valve is restored. U.

Byssonychia obesa Ulrich.. 991

8-8b. Three views of a cast of the interior of the medium size, from Richmond, Indiana. U.

Bucania simulatrix Ulrich.. 955

9-9a. Two views of this species. From Richmond, Indiana. U.

*Figures after Miller and Dyer.

**Figures after Miller and Faber.

Plate XLII.

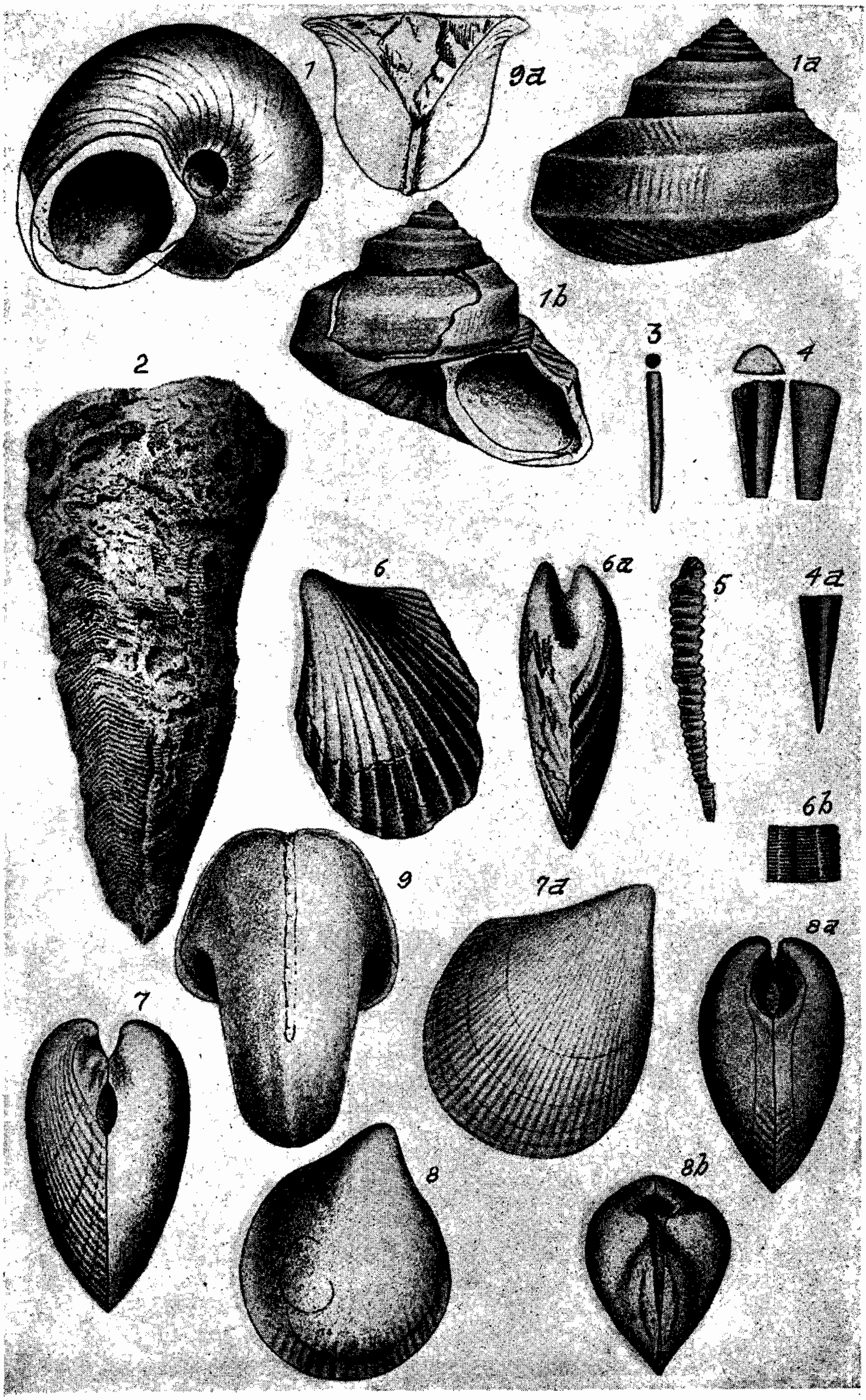

PLATE XLIII.

Page

Anomalodonta gigantea Miller.. 988

1. Very good cast of the interior of a left valve, with the ligamental area restored. U.

1a and 1b. Internal views of the original types of the genus and species, from Versailles, Indiana. U.

Allonychia jamesi Meek.. 986

2. An excellent cast of the interior of the right valve of this species. U.

Byssonychia praecursa Ulrich.. 992

3 and 3a. Two views of the type. U.

Byssonychia radiata Hall.. 993

4. Exterior of the left valve, showing the surface markings. Hall and Whitfield.

Byssonychia tenuistriata Ulrich.. 996

5 and 5a. Two views of the type, from Granger, Minnesota. U.

Plate XLIII.

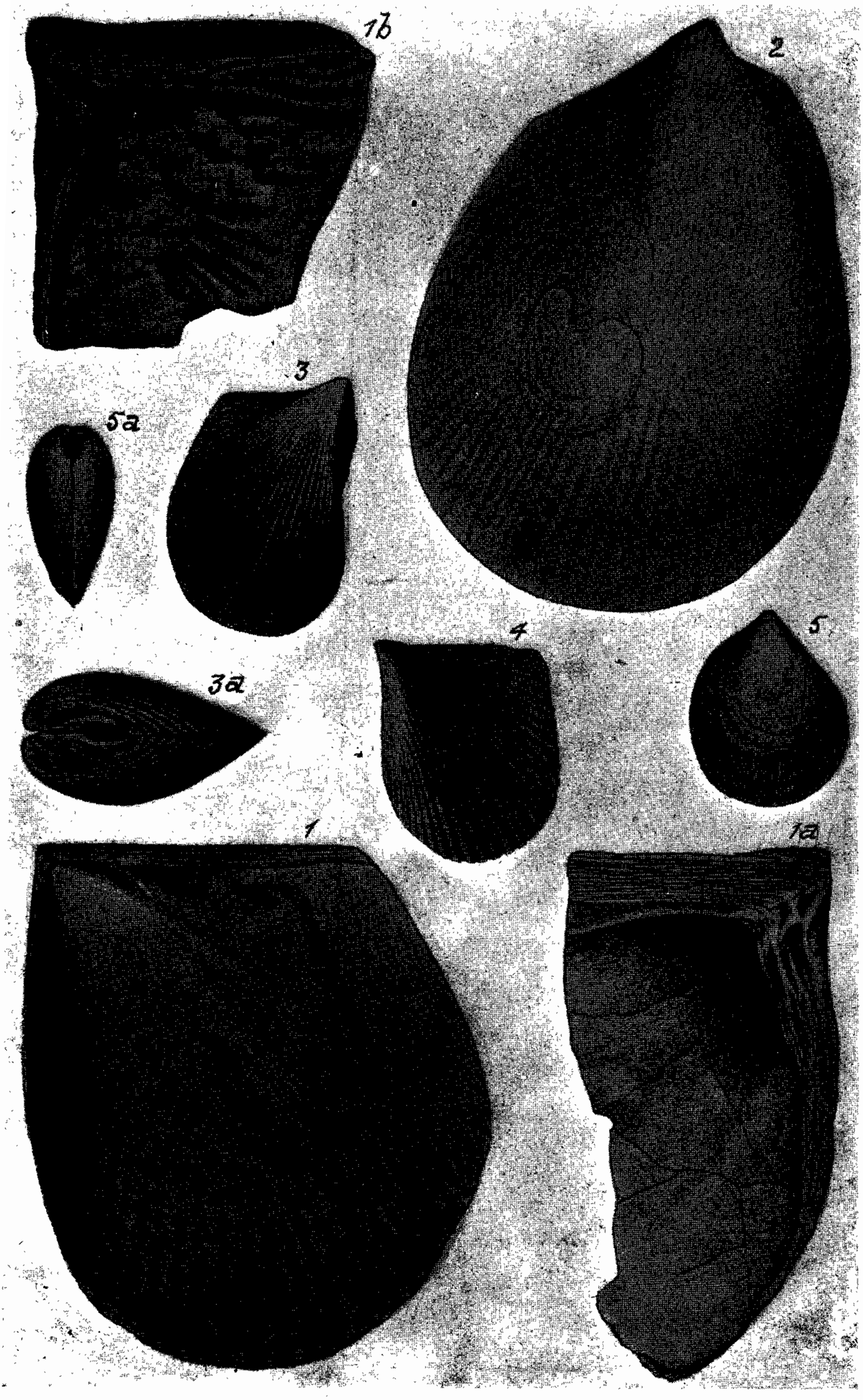

PLATE XLIV.

Page

Byssonychia grandis Ulrich.. 990

1 and 1a. The left valve and anterior view of an imperfect and slightly distorted cast of the exterior, from the Richmond formation at Oxford, Ohio. U.

Byssonychia richmondensis Ulrich................................ 994

2 and 2a. Two views of a cast of the interior of the average size and proportions, from Richmond, Indiana. U.

Byssonychia suberecta Ulrich...................................... 995

3. An imperfect testiferous right valve. U.

3a. Anterior views of two valves from the Richmond formation at Versailles, Indiana. U.

Clionychia excavata Ulrich... 997

4 and 4a. Lateral and anterior views of a cast of the interior. The thickness doubtless reduced by pressure. U.

Ctenodonta cingulata Ulrich.. 997

5. Exterior of a right valve. U.

5a. Interior of same. x 2. U.

Clidophorus fabula Hall.. 996

6 and 6a. Lateral and cardinal views of this species. M.

Plate XLIV.

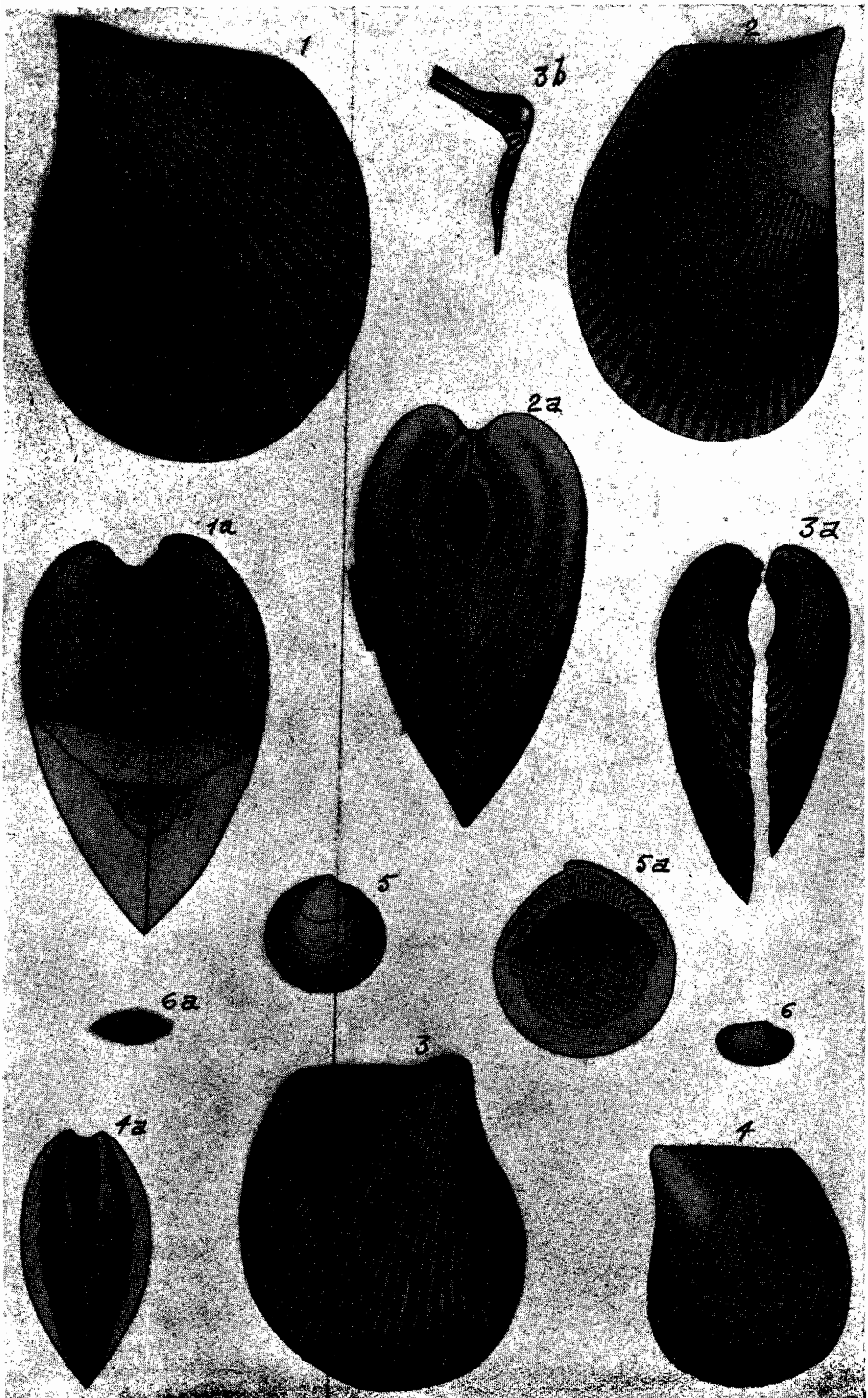

PLATE XLV.

Page

Cymatonota typicalis Ulrich 998

1 and 1b. Left side and dorsal views of an imperfect cast of the interior, from Waynesville, Ohio. U.

1a. Left side of a nearly complete cast of the exterior. U.

1c. Dorsal view of same in outline. U.

Cyrtodonta cuneata Miller 999

2. View of the type. Miller.

Ischyrodonta decipiens Ulrich 999

3, 3b and 3c. Three views of a nearly perfect right valve. U.

3a. Interior of the largest left valve seen (by Ulrich). Near Richmond, Indiana. U.

Ischyrodonta elongata Ulrich 1000

4. Left valve of the original type of the species. U.

4a. Smaller mold of the exterior, from Richmond, Indiana. U.

Ischyrodonta miseneri Ulrich 1001

5. Right side of a specimen from Richmond, Indiana. U.

Ischyrodonta modioloformis Ulrich 1001

6. Small example of this species, differing somewhat, especially in the basal region, from the typical form of the species. U.

6a. The right side of a nearly perfect cast of the interior. U.

6b. Dorsal view of another cast of the interior. U.

6c. From a gutta-percha impression of a portion of the exterior. x 2. U.

Ischyrodonta ovalis Ulrich 1002

7-7b. Three views of the original type of this species. U.

Ischyrodonta truncata Ulrich 1003

8-8c. Various views of this species. U.

Plate XLV.

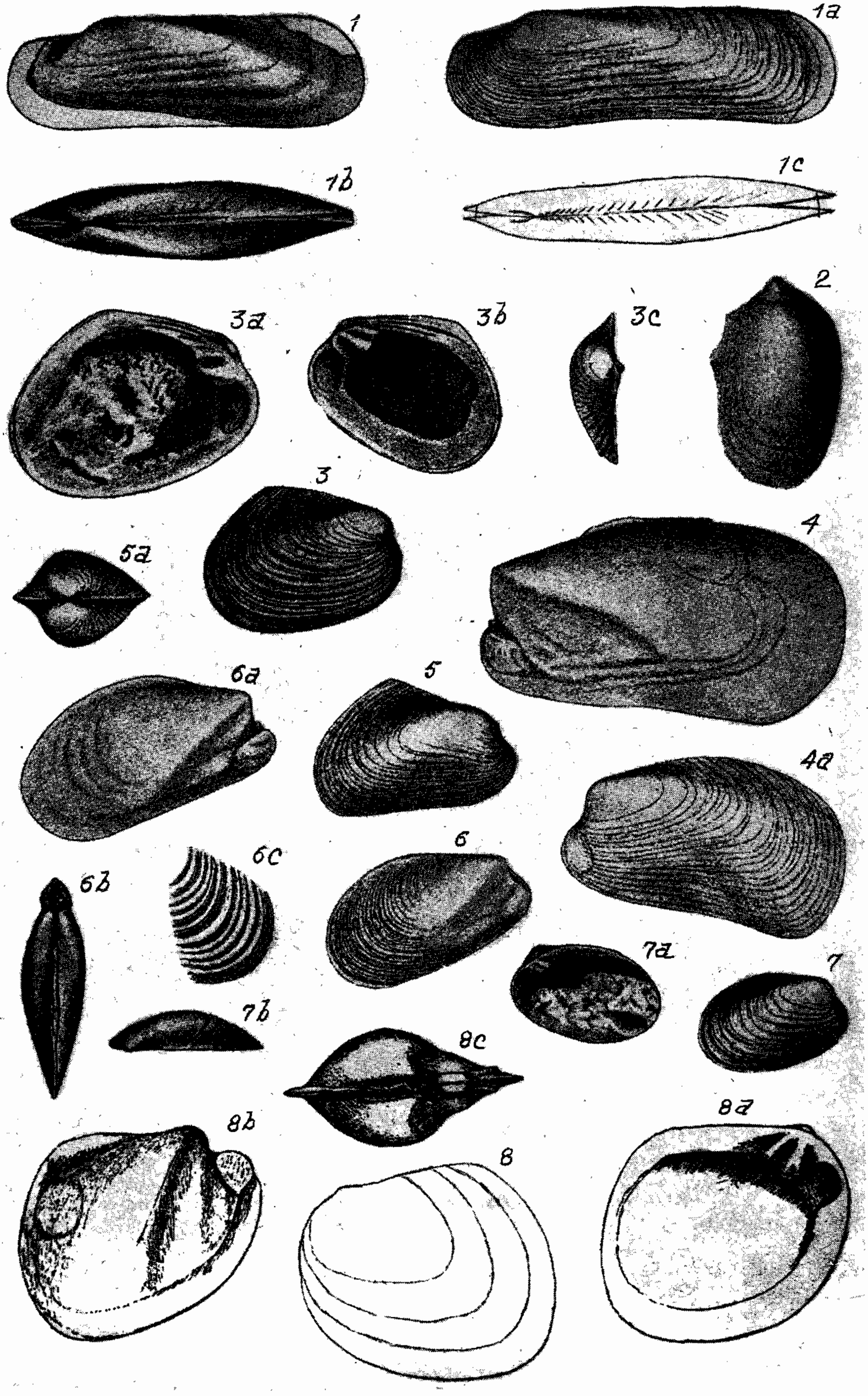

PLATE XLVI.

Page

Ischyrodonta unionoides Meek.................................. 1004

1 and 1a. Two views of the type. M.

Modiolodon declivis Ulrich.. 1005

2 and 2a. Right side and cardinal view of a cast of the interior of a specimen from Richmond, Indiana. U.

Modiolodon subovalis Ulrich...................................... 1006

3. Left side of a cast of the interior, From Versailles, Indiana. U.

3a and 3b. Right side and cardinal view of a cast from the Richmond formation at Versailles, Indiana. U.

Modiolodon obtusus Ulrich.. 1005

4 and 4a. Impressions of the exteriors of a left and right valve of this species from Cincinnati, Ohio. U.

Modiolodon subrectus Ulrich...................................... 1007

5 and 5a. Left side and cardinal view of a small but characteristic cast of the interior. Richmond, Indiana. U.

Modiolodon truncatus Hall.. 1008

6. The right side of an internal cast from Versailles, Indiana. U.

6a. Left side of a cast of the interior from Cincinnati, Ohio. U.

Modiolopsis versaillesensis Miller................................ 1010

7 and 7a. View of the exterior of a left valve and the interior of a right valve of this species. Miller.

Plate XLVI.

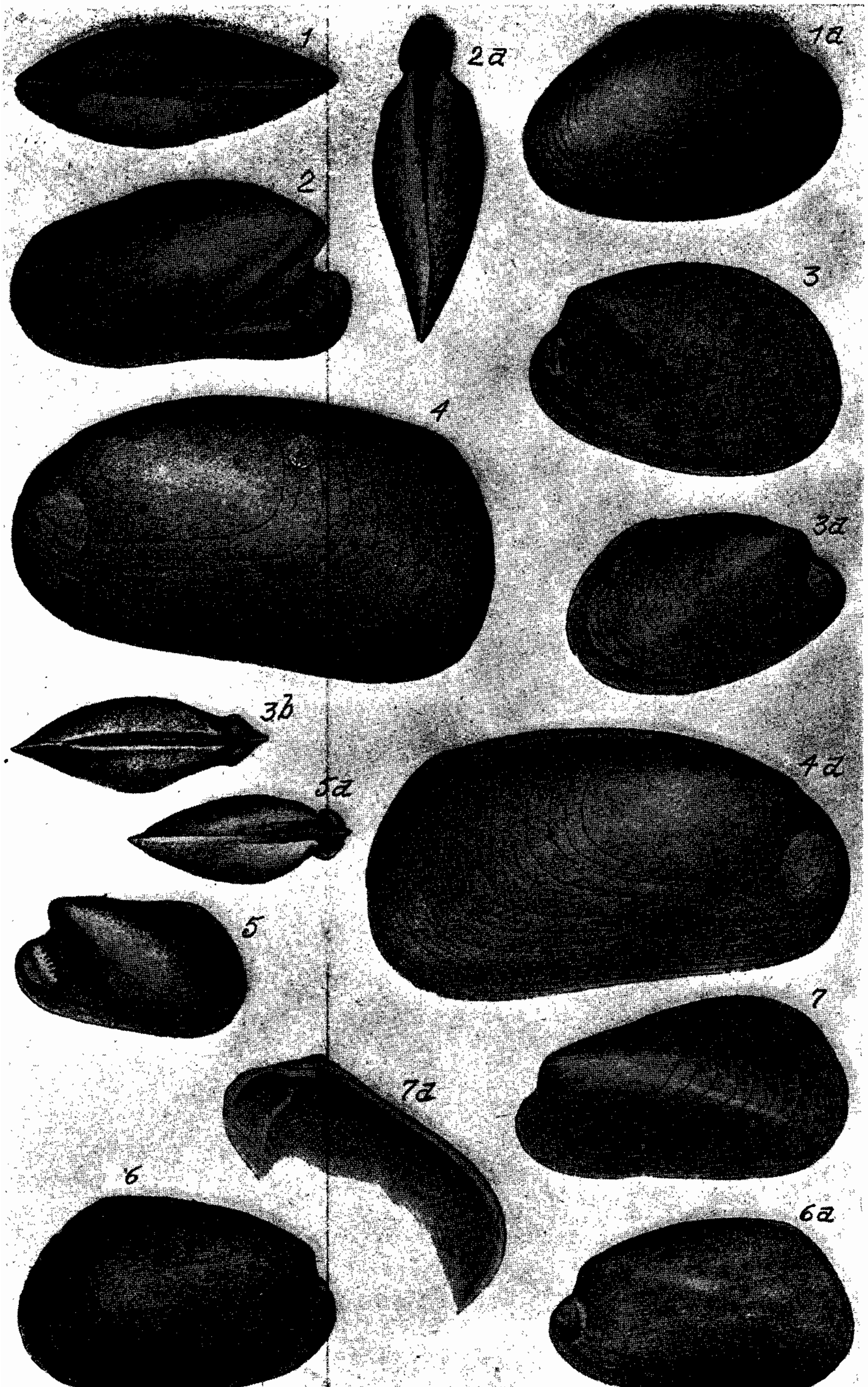

PLATE XLVII.

Page

Opisthoptera casei Meek and Worthen 1011

1. Gutta-percha impression of a natural mold of the exterior of a specimen from Marion county, Kentucky. U.

1a. Left side of a cast from Richmond, Indiana. U.

Opisthoptera obliqua Ulrich 1012

2. Right side of a specimen from Richmond, Indiana. U.

2a. Anterior view of the same. U.

2b. Dorsal view of a good cast from Richmond, Indiana. U.

Modiolopsis concentrica Hall and Whitfield 1009

3. View of a small specimen retaining both valves and showing the surface markings. H. and W.

Orthodesma canaliculatum Ulrich 1012

4 and 4b. Right side and cardinal views of a nearly perfect cast of the interior. Waynesville, Ohio. U.

4a. Incomplete cast of the anterior end, showing obscure rays across the central half. U.

Orthodesma parallelum Hall .... ——

5. Right side of the type. Hall.

Orthodesma rectum Hall and Whitfield 1014

6 and 6a. Right sides of two specimens showing the range in size. H. and W.*

Orthodesma subangulatum Ulrich 1015

7 and 7a. Left side and cardinal views of a specimen from Richmond, Indiana. U.

Orthodontiscus milleri Meek 1015

8. Interior of a left valve of a large specimen. M.

8a and 8b. Left side and dorsal view of a medium sized specimen. M.

Ortonella hainesi Miller 1017

9. Right side of a perfect, though rather small, and typical specimen. U.

9a. Antero-dorsal view of same. U.

9b. Interior of a left valve. U.

9c. Nearly entire mold of the interior of a right valve showing impressions of the posterior lateral teeth. U.

9d. Dorsal view of an excellent cast of the interior. From Richmond, Indiana. U.

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*Figures after Hall and Whitfield.

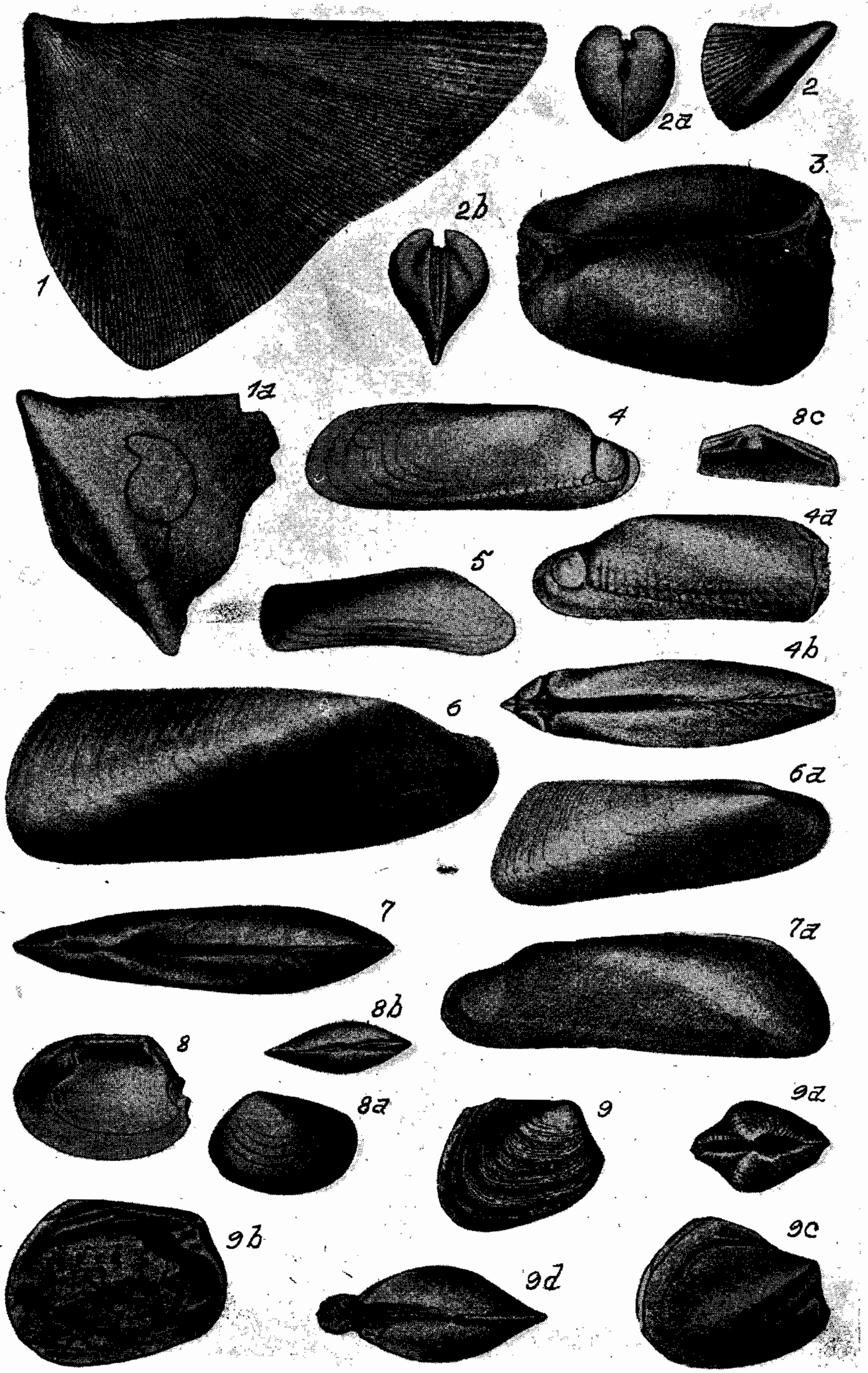
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PLATE XLVIII.

Plate XLVIII.

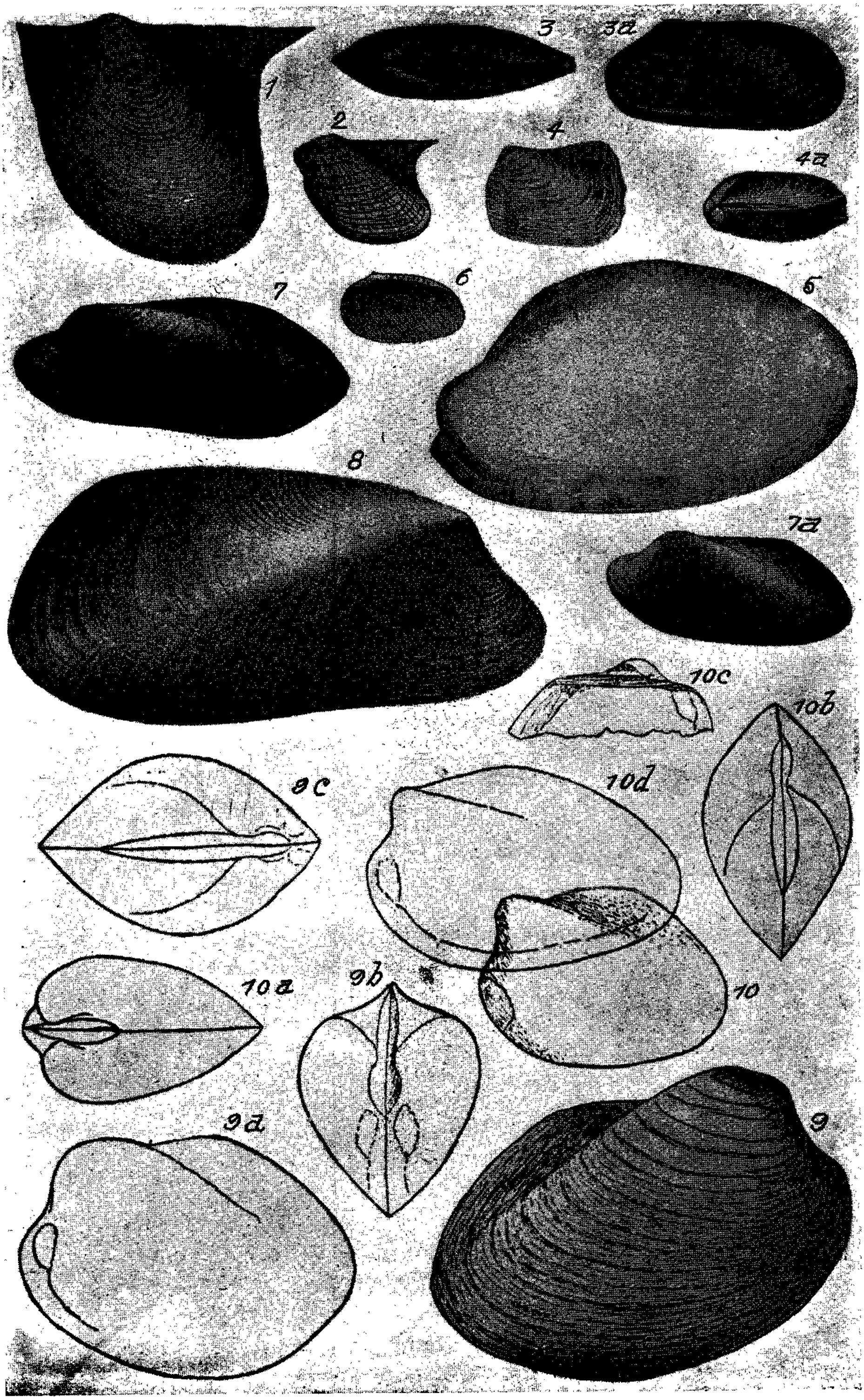

PLATE XLIX.

Plate XLIX.

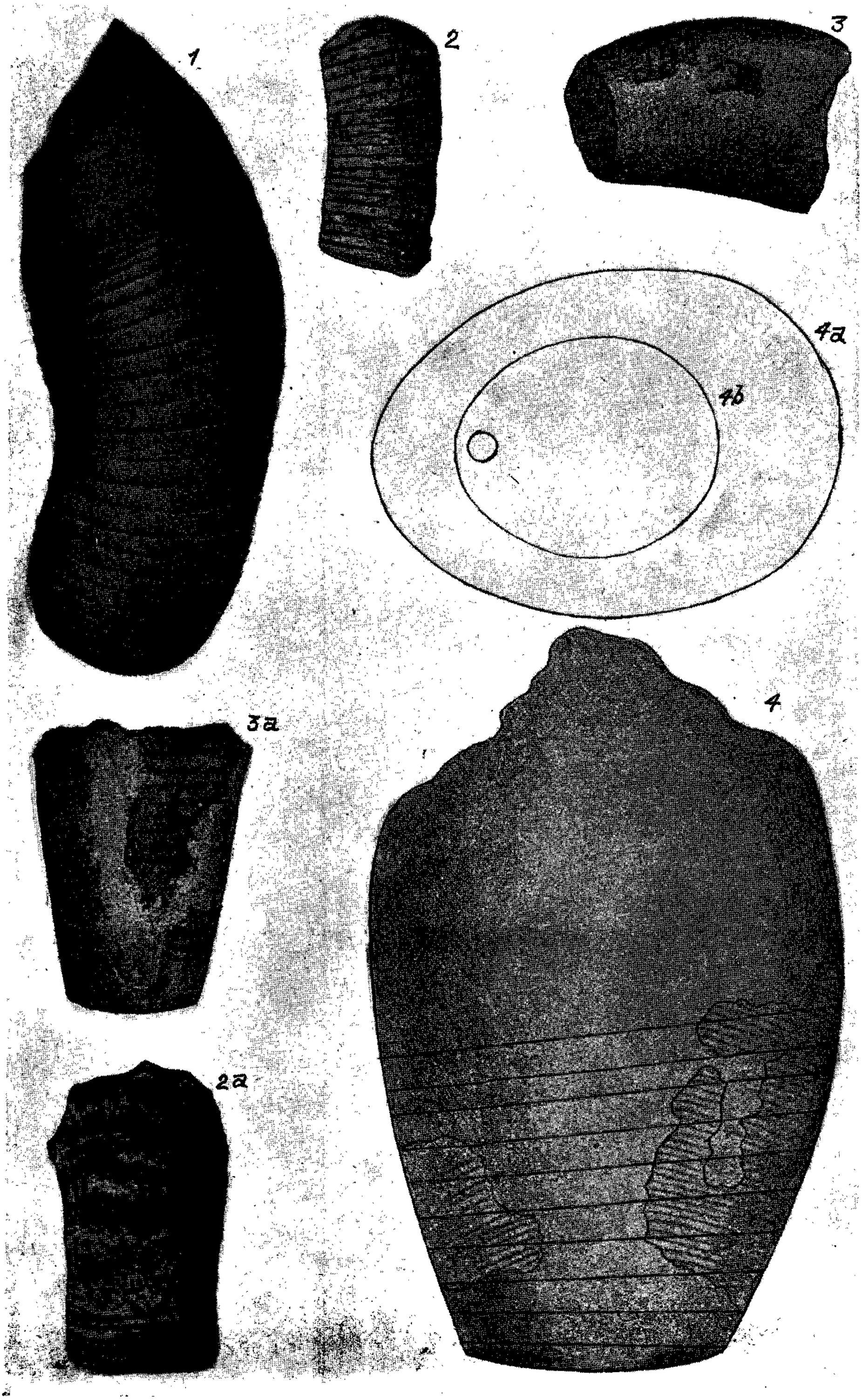

PLATE L.

Page

Endoceras proteiforme Hall 1029

1. Specimen showing the siphuncle with portions of several of the camerae still in position. Hall.

1a. A similar specimen giving a natural section of the camerae. H.

1b. View of a similar specimen. Siphuncle somewhat broken. H.

1c. Specimen showing twelve camerae. H.

1d. Transverse section of the last. H.

Plate L.

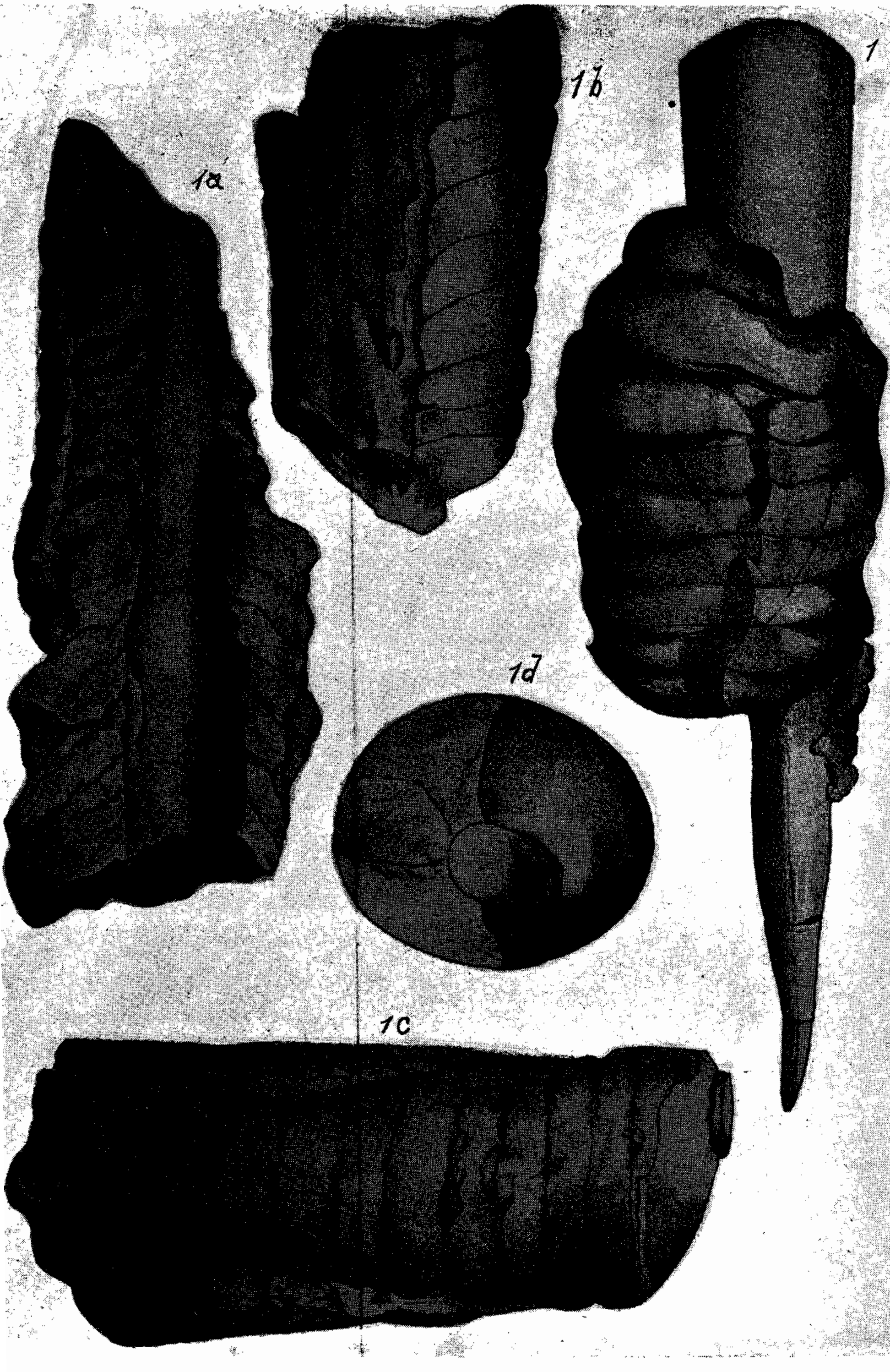

PLATE LI.

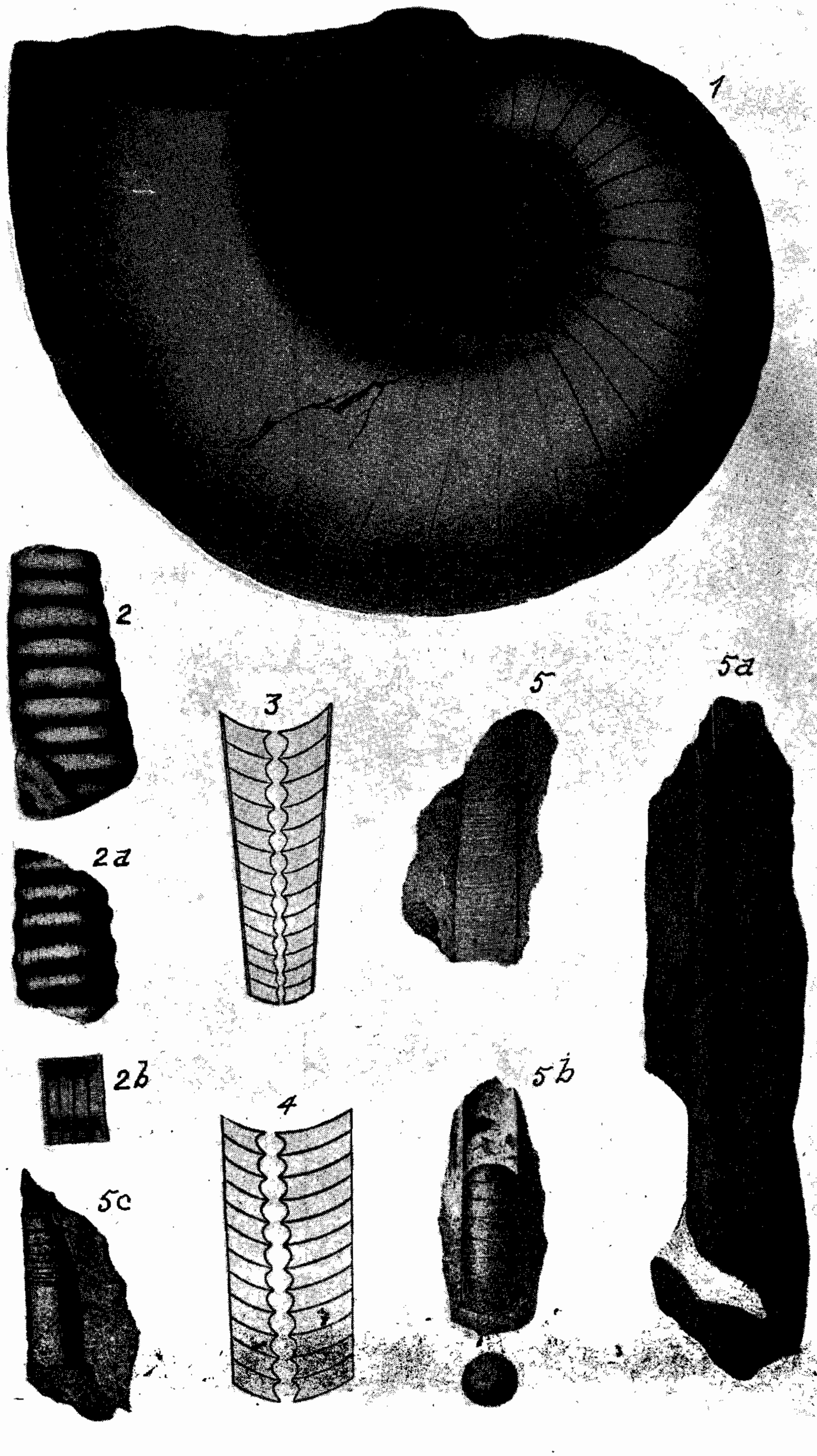
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Plate LII.

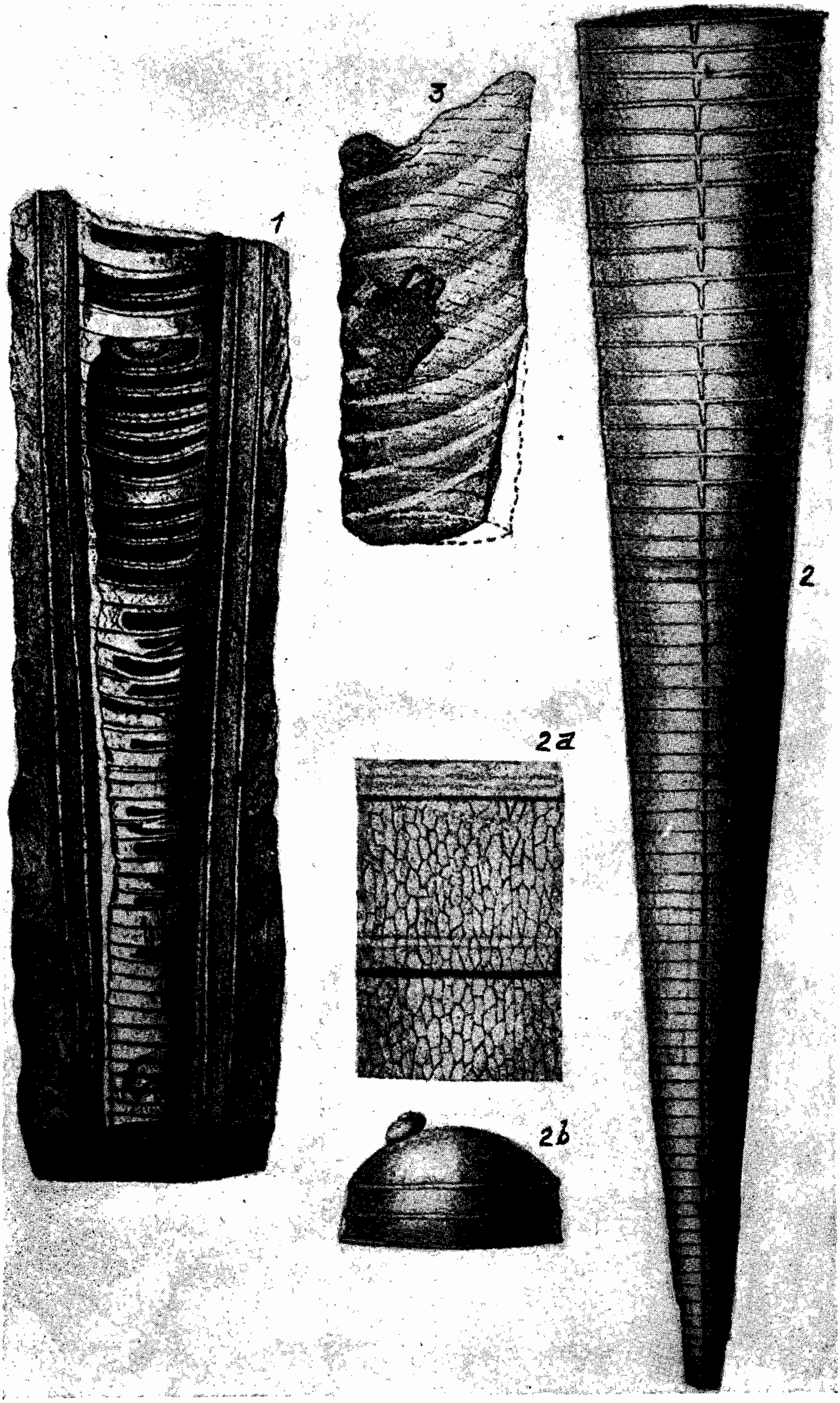
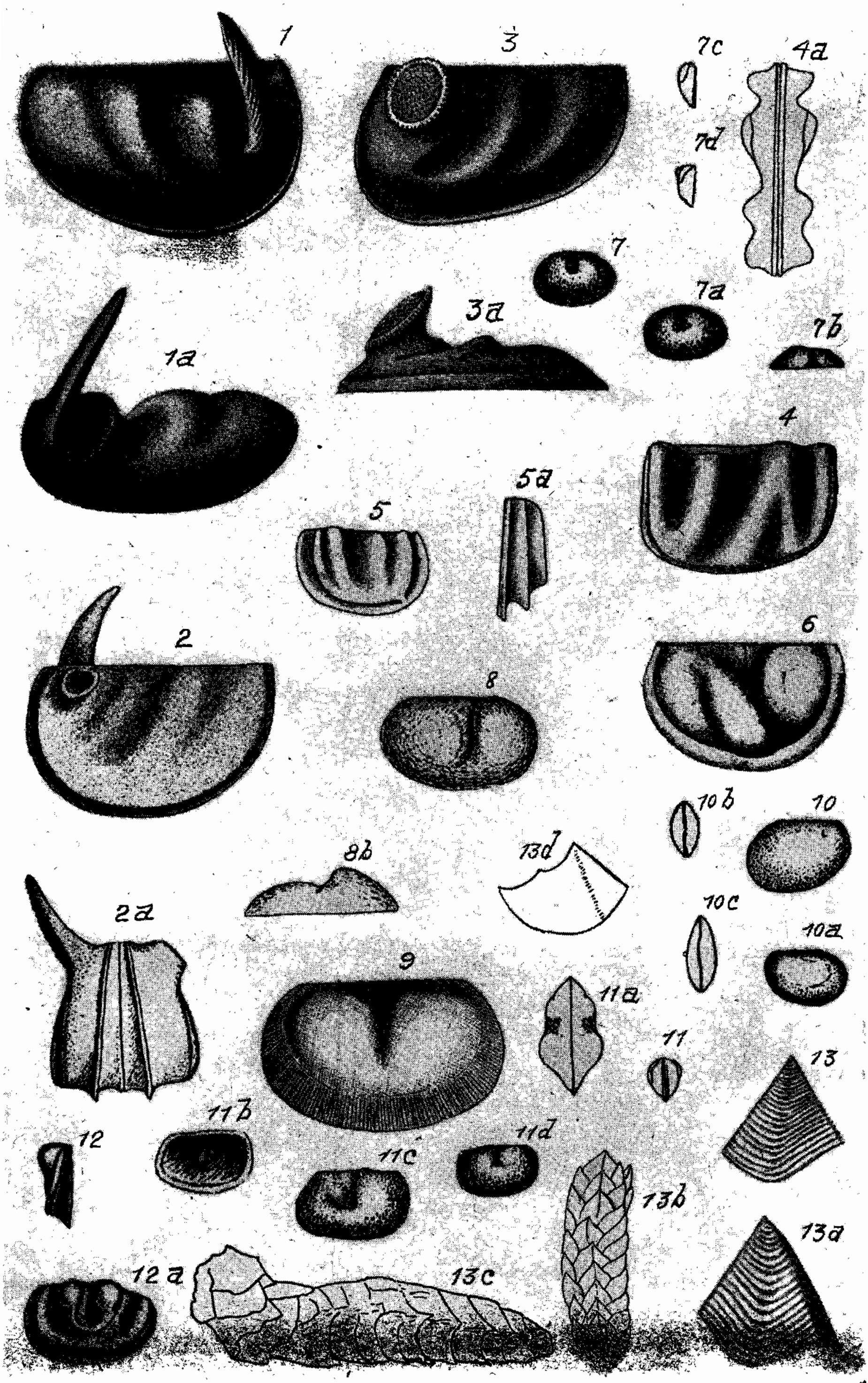


PLATE LIII.

Plate LIII.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Page

Lepidocoleus jamesi Hall and Whitfield.......................... 1050

13-13a. Detached plates of this species from Cincinnati, Ohio, greatly enlarged. H. and W.

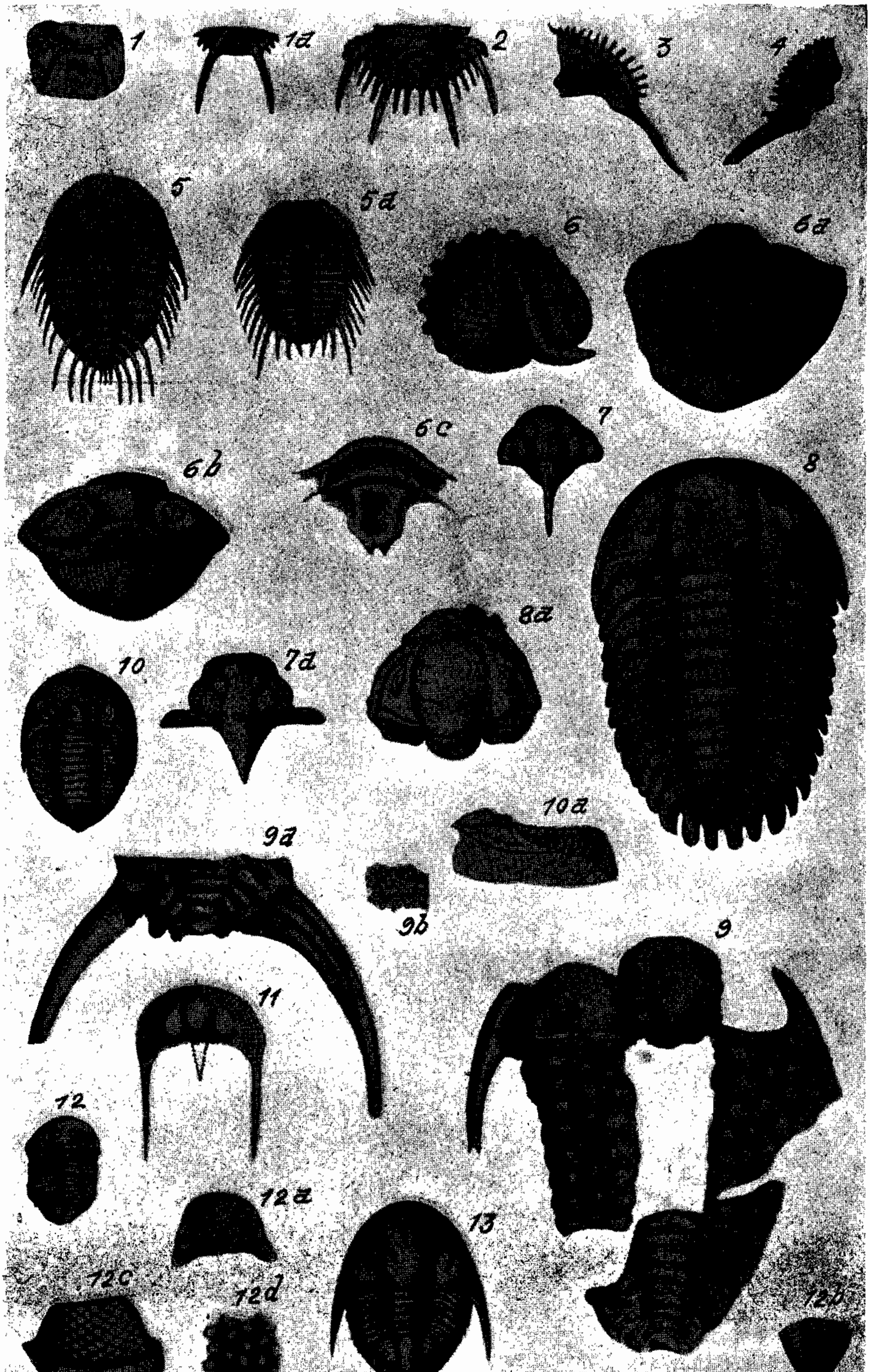
13b. An outline of a very perfect specimen (after Woodward), supposed by Hall and Whitfield to be congeneric with their *Plumulites jamesi*, but evidently not to be so considered.

13c. An entire example of this species. Outline drawing from a figure by Faber.

13d. One of the plates of same specimen. Outline after Faber.

PLATE LIV.

Plate LIV.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Page

Dalmanites callicephalus Hall.. *

12. View of a complete specimen of this species. H.

12a. Enlarged view of the cephalon. H.

12b. Pygidium. H.

12c. Enlarged view of one of the eyes, showing the facets. H.

12d. Portion of the surface magnified. H.

Proetus spurlocki Meek.. 1062

13. A specimen with the cephalon slightly injured by abrasion, and slipped slightly backward so as to hide one or more of the thoracic segments. M.

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*This is a Trenton species.

PLATE LV.

1. View of a nearly perfect specimen of this species, but with the test more or less exfoliated so as to show the hypostoma. From the Trenton limestone of New York. H.

Plate LV.