

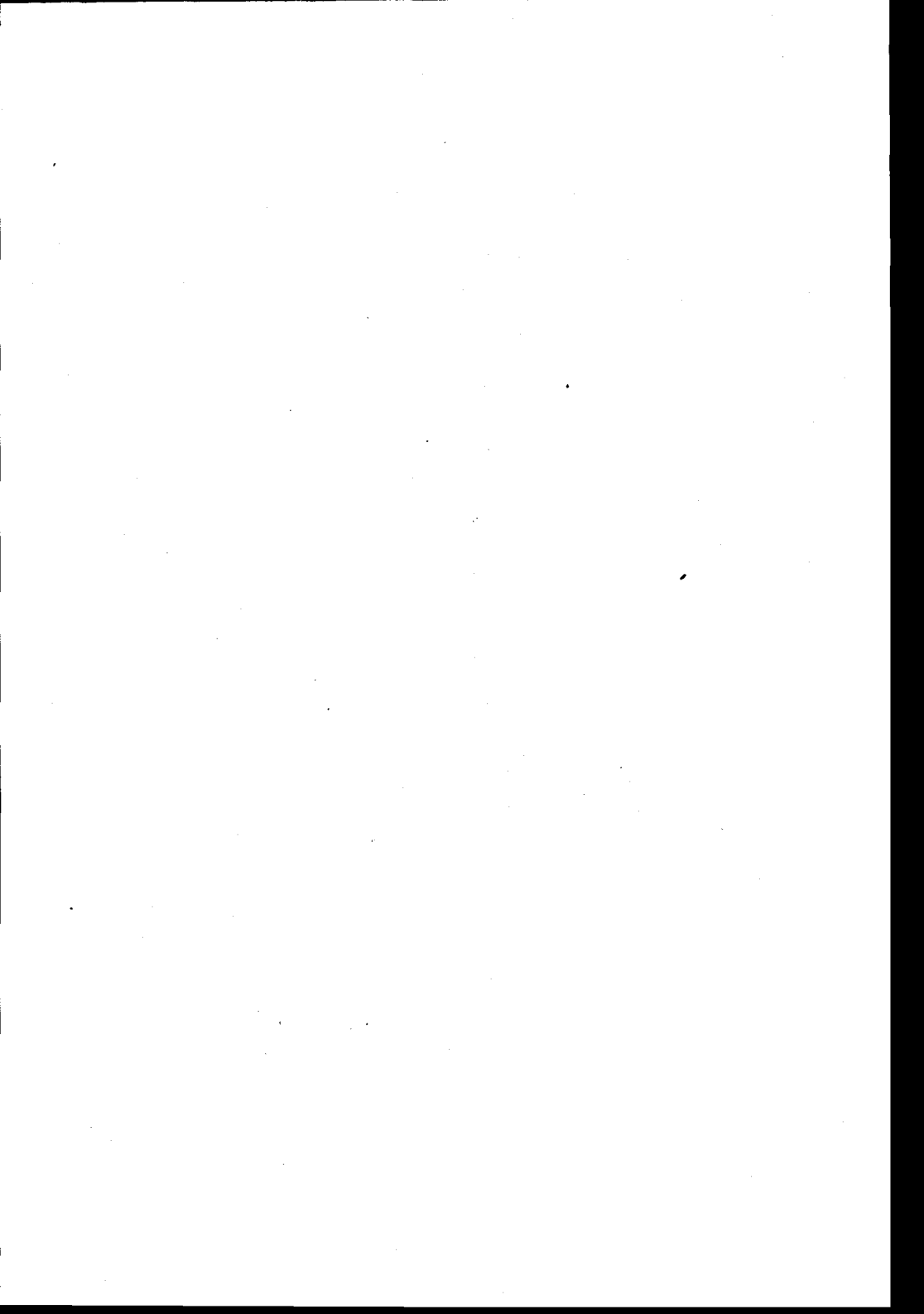
FAUNA  
OF THE  
Salem Limestone  
OF INDIANA.

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# FAUNA OF THE SALEM LIMESTONE OF INDIANA.

## INTRODUCTION.

BY E. R. CUMINGS AND J. W. BEEDE.\*

A portion of this fauna has been well known since Hall's description of it appeared in the transactions of the Albany Institute† in 1856. These descriptions were published without illustrations, and were republished with very valuable comments and excellent lithographic illustrations by Whitfield, in 1882, in Bulletin 3, Volume I, of the American Museum. These plates were republished by Hall, with his original descriptions, in the 12th annual report of the Indiana Survey in 1882. Most of the remainder of this remarkable fauna has been brought to light, a species here and another there, and published in the leading geologic periodicals and reports of this country and Europe, in such a manner as to be practically inaccessible to any one in the State wishing to take up its study, and some of the material, especially the Bryozoa, has never been described and figured at all.

It is the object of these papers to assemble, describe and illustrate, as nearly as may be, all the species of this fauna and pass it in such a critical review as the time and means at our disposal will permit.

The fossils treated are limited to those occurring in the State of Indiana and the stratum of limestone known under the various names of "Bedford oölitic limestone," "Indiana oölite," "Warsaw limestone," "Salem limestone," and "Spergen limestone" recently proposed by Mr. E. O. Ulrich without any warrant whatever. The discussion of the nomenclature of this limestone will be taken up later by the writers. The outcrop of this limestone is accurately shown on the map recently issued by the Indiana Survey, and its characters and occurrence have been thoroughly discussed

\*The order of these names is without significance.

†Trans. Alb. Inst. IV, 1856.

by Hopkins and Siebenthal in the twenty-first annual report of the Indiana Survey, 1897. This limestone rests upon the Harrodsburg limestone, which is the basal limestone of the Indiana Mississippian, in the northern part of its outcrop and upon a shale in a large portion of its southern outcrop, as at Spergen Hill and Lanesville. At the former locality there is a depositional unconformity, mentioned later. The formation is, in a very broad way, rather lenticular in its occurrence, pinching out in at least 2 places and attaining a thickness of 50 or 60 feet in the vicinity of Bedford. Where typically developed it is oölitic or semioölitic in structure and frequently noticeably cross bedded.

The fossils of this limestone in its typical development are characterized by their stunted form and extreme abundance. Many of these species are found in the rocks above or below and are then of normal size, usually several times as large as their representatives found in the Salem limestone. In exceptional cases, in favorable locations, the species in this horizon reach nearly or quite normal size. Sometimes at the base of this limestone, as at the type locality at Spergen Hill, the very base of the formation is peopled with the fossils typical of the limestone below, but these are quickly replaced by the typical Salem fauna. In some instances the corals, brachiopods, etc., reach normal size in the very top of the formation, as at Bedford and Bloomington, and in such cases the typical fauna has again disappeared to a very large extent, as will be shown later. In these cases the fossils undoubtedly lived in quiet water where the sediment settled upon them rapidly, and the rocks, apparently, never thoroughly consolidated, leaving the fossils in a most excellent state of preservation, in a matrix very soft and easily removed without injury to the most delicate specimens. In this condition great fronds of bryozoa as much as 18 centimeters in diameter have been found and developed, and brachiopods with double-barreled, barbed spines a half inch long are to be obtained.

Fossils are to be found in greater or less abundance most anywhere along the outcrop of the formation, but at certain localities they are extremely abundant. Following is a brief mention of the more celebrated of these localities:

At Lanesville, Harrison County, save at some exposures of this rock where a few fossils are found in the matrix, the fossils are



found in the red clay banks which are the result of the disintegration of the limestones.

Paynters Hill, 3 miles east and 2 miles south of Salem, Washington County, is a low knoll at the forks of the road, the top of which is made up of red clay, derived from the decay of the limestone and the layer of chert which once formed the top of the Salem limestone at this point. This clay teems with fossils silicified upon weathering from the limestone. Corals and echinoderms appear to be more susceptible to silicification under such conditions than pelecypods and gastropods and the like, and as a result the former make up the bulk of the fauna preserved here. The fossils are best secured by shipping large amounts of clay to the laboratory and carefully washing it.

The Spergen Hill cut is located on the C. I & L. R. R. about  $\frac{1}{4}$  of a mile south of Norris Station, Washington County, on the east side of Spergen Hill. The cut exposes practically the full thickness of the limestone. The base of the oölite here is very uneven and undulating, resting in part on the masses of limestone but mostly on shale where the limestone had been carried away and the shale deposited. The very base of the Salem limestone, particularly in the north end of the cut, carries a Harrodsburg limestone fauna intermingled with the Salem limestone fauna, which quickly replaces the former. At or near the top of the stratum is a layer of chert or silicified limestone. The best preserved specimens are to be had by soaking and breaking up the more rotten portions of the limestone into small particles in the laboratory and selecting the fossils after carefully washing the material. At the top of the cut on the east side is a considerable amount of red clay, some of it in situ, resulting from the solution of the limestone, in which there are many species of beautifully silicified fossils, rare in the stone below.

At Bedford, Lawrence County, the best fossils occur in the region of the Dark Hollow quarry, reached on the Bedford and Bloomington branch of the Monon R. R. They occur in the "top bastard" stone of the quarrymen. This is a transitional layer between the quarry stone and the Mitchell limestone above. Large brachiopods, bryozoans, and corals abound.

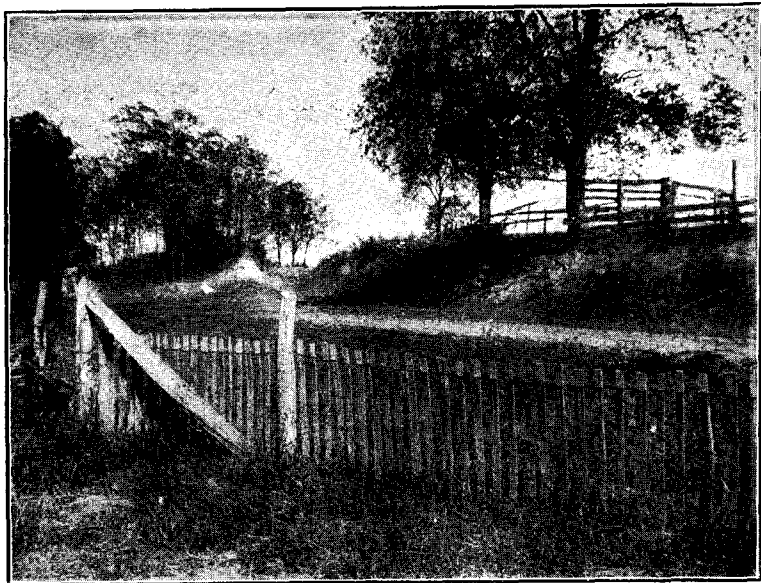


Fig. 1. The locality at Paynters Hill. The white collecting sack in the left of the picture represents the principal locality with the shade of the big tree on the left side of the road.

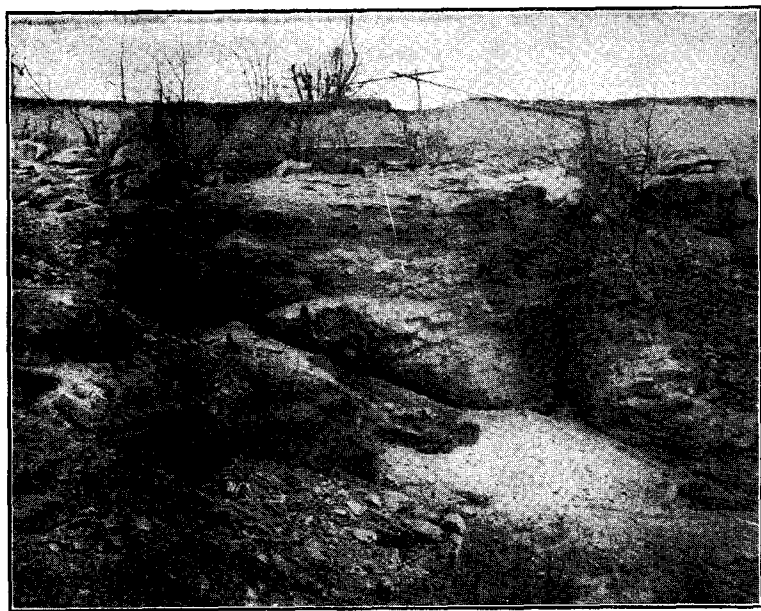


Fig. 2. The old Cleveland quarry at Harrodsburg. The main part of the quarry is not shown in the picture. The pile of white sand in the foreground is merely a pile of fossils disintegrated off the limestone block above with an admixture of dirt and the calcite cementing material of the stone.

Plate II.

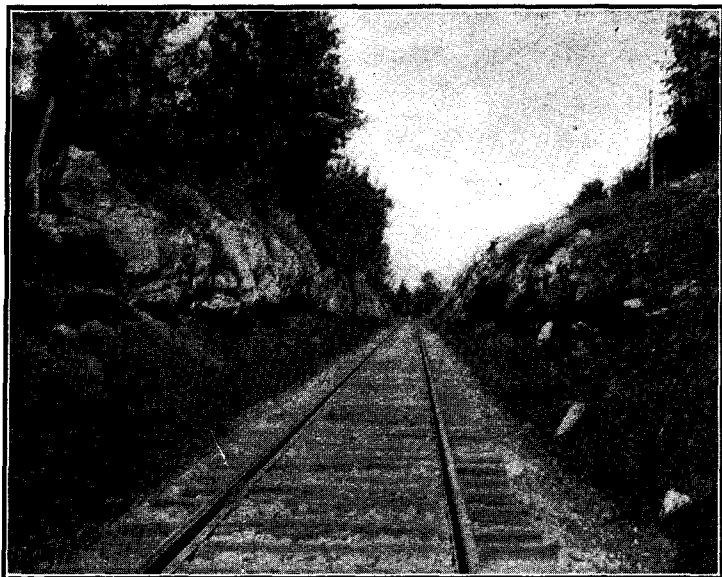


Fig. 1. The cut at Spergen Hill.



Fig. 2. The outcrop of the Salem limestone at Lanesville. About three feet thick at this place.

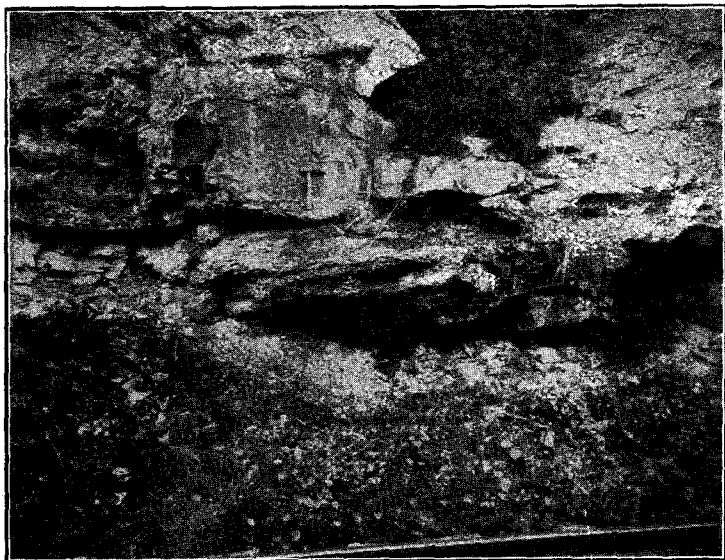


Fig 1

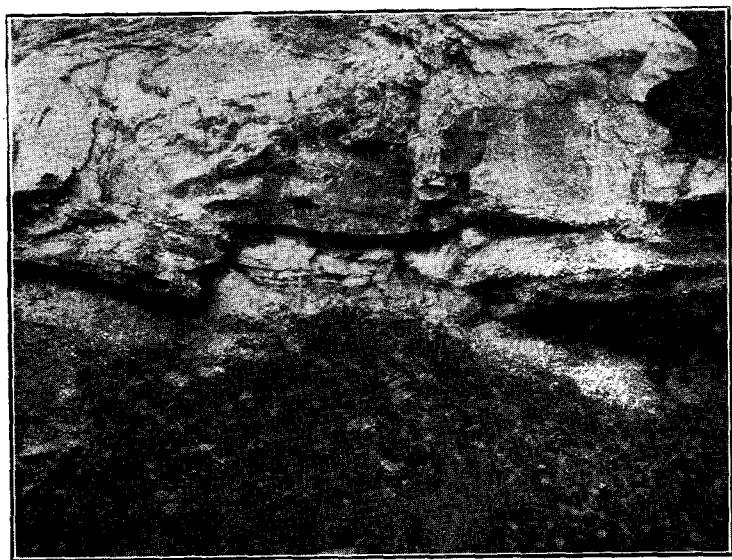


Fig. 2.

Figs. 1 and 2. Two slightly different views of the west side of the cut at Spergen Hill showing the uneven base of the limestone and the remnants of a limestone lens and the surrounding shale on which the Salem limestone rests.



Fig. 1.



Fig. 2.

Two scenes from the Big Creek Quarries.

Plate V.

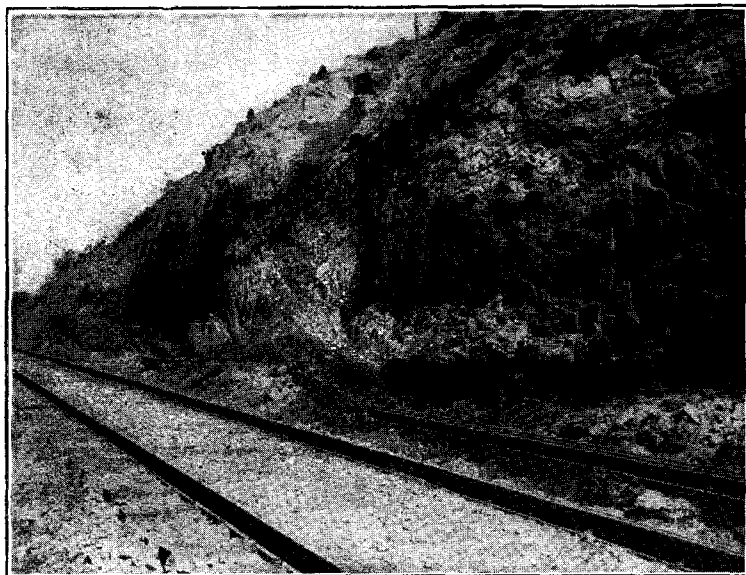


Fig. 1. The east side of the cut showing the scaling off by weathering. These small slabs soaked and hammered up yield the most perfect fossils to be had at Spergen Hill.

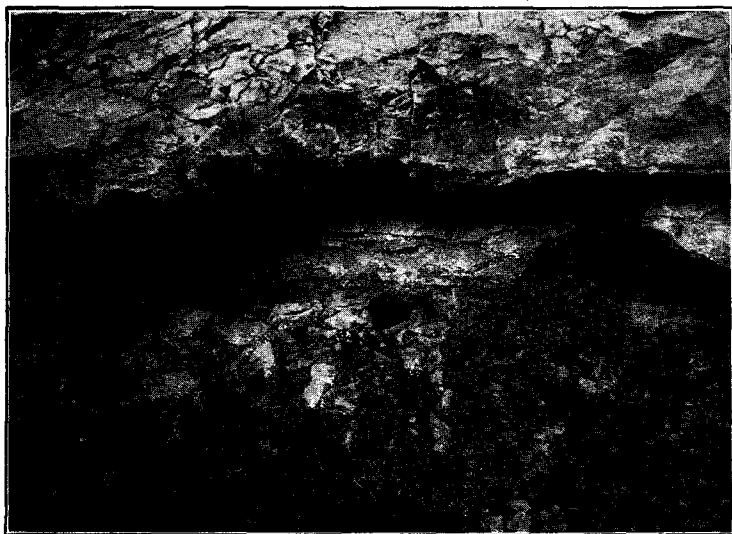


Fig. 2. Illustrates the uneven contact of this limestone and the underlying shales and limestones. West side of cut at Spergen Hill.

A little over a mile northwest of Harrodsburg, Monroe County, is the abandoned "Cleveland quarry." At this place the limestone crumbles very rapidly to sand composed almost entirely of organic remains with the crystalline calcite cement of the stone. Large amounts of this sand are formed each year and millions of specimens of the typical fauna, greatly stunted, are to be had each spring.

The collecting locality at Bloomington, Monroe County, lies 3 miles northwest of the city in the abandoned quarries in the "Hunter Valley" district. Here large slabs literally filled with the most delicately preserved specimens have been found, producti and other spinous species, with all the spines intact are to be had.

At Ellettsville, Monroe County, in the Matthews quarry, at a certain horizon near the top is a layer rich in fossils, many of them of normal size; sometimes blocks of large size are found almost entirely composed of shells which break out fairly well when the rock is soaked and hammered up.

The Stinesville, Monroe County, locality is on Big Creek, a mile or more northwest of the station, at the abandoned quarry. The fossils are most abundant on the south side of the creek on the ledge just opposite the site of the old mill. Here many of the fossils, in good state of preservation, are weathered out free in the calcareous earth.

The most of the scanty fauna found at Romona, Owen County, is to be found in the abandoned quarry north of the ravine, just north of the town.

The fauna is best developed at the classic old railroad cut at Spergen Hill and in the region thereabout. Many of the corals, crinoids and other fossils that occur in this southern region never reached as far north as Bedford and Bloomington.

Ulrich expresses the belief that this is a pelagic fauna, and in his remarks concerning the reappearing of a part of this fauna in the Ste. Genevieve limestone states: "The writer does maintain, however, that the forms thus reappearing are members of a single slowly modifying and largely pelagic fauna that existed continuously elsewhere and entered this epicontinental basin only when conditions were favorable. One of these conditions involved the deposition of the oölitic limestones. Another probably was the

Plate VI.



Slab of Fossiliferous Limestone from Bloomington. About natural size.



subsidence or modification of barriers, allowing communication with seas more permanently inhabited by the invading fauna.”\*

The reappearance of a fauna with the re-establishment of favorable conditions is to be looked for in the formations of any epoch. This is most strikingly shown in regions where conditions favorable and unfavorable to a given fauna alternated through considerable lengths of time, as in the Pennsylvanian rocks of eastern Kansas. In the latter case, at least, the recurrence is faithfully repeated many times through over 2,000 feet of rocks. The modification of any one fauna throughout this great range is quite as gradual as that mentioned above, but, nevertheless, modification does exist, and to an appreciable extent, so that when the species are taken with regard to their relative abundance, their horizon can be determined. However it does not necessarily follow that such faunas are pelagic, and we are of the opinion that most of the “Spergen fauna” reappearing in the Ste. Genevieve rocks above referred to are not pelagic in the usual sense of that term.\*

Our reasons for thinking so are: The Salem limestone is highly cross-bedded. The fossils, aside from exceptional localities, are waterworn and usually ground to fragments. Many of the fossils, including a large percentage of those enumerated by Ulrich, occur of normal size in the rocks above or below.

It seems to the authors that the cross-bedding of the rock, its water-worn fossils, the fact that they are stunted, and the oölitic or semi-oölitic character of the rock, wherever typically developed, precludes the idea of its pelagic origin and argues forcibly in favor of a semi-littoral or lagoonal origin, as is also indicated by its broadly lenticular occurrence, a condition unfavorable to the existence of billions of pelagic organisms through a considerable length of time.

In general the gastropods and brachipods found in the Salem limestone are forms indicative of shallow conditions, such forms as

\*U. S. Prof. Pap. 36, p. 49, 1905.

\*The following definition of the term pelagic as used in geology is given by the eminent paleontologist Felix Benard: “The idea of the pelagic facies [in geology] is broadened, and we refer to this facies the deposits formed in the deep sea, at a considerable distance from the shore, but not in the abyssal depths; they are characterized by the absence of the elements of the fauna of the littoral zone, and by a mixture of the forms adapted to swimming, such as cephalopods, pteropods, fishes, with creeping or fixed faunas (echinoderms, brachiopods, gastropods, Lamelli-brachs), the species of which differ from those living near the shore.” Translated by C. E. Brooks, from the 14th annual report of the State Geologist of New York. 1895.

might inhabit coral reefs and lagoons where there is considerable agitation of the water. The Bryozoa when perfect, as at Bedford, abound in strong brace roots, anchoring spines, and all the paraphernalia indicative of agitation of the water. The foraminifera and small ostracods which are so conspicuous an element of the Salem fauna were swept in by currents from the open sea, as such pelagic organisms are now brought by the gulf stream to the coral banks of southern Florida. Their presence in a geological formation does not furnish any conclusive evidence one way or the other as to the littoral or pelagic origin of the fauna.

With the addition of the Bryozoa, *Zaphrentis cassedayi*, and a few other species, the fauna originally described by Hall may be considered as the typical fauna of the Salem limestone. Nevertheless any list of species, however complete, gives a very inadequate idea of the nature of the fauna as it really exists. It is only when the relative abundance of the species is graphically represented and their stunted condition kept in mind that the true conception of the fauna can be had and the characteristics brought out which at once sharply distinguish it from any other fauna of the Mississippian rocks.

The large part of the time was spent in the study of the corals, bryozoans, etc., not represented in the works of Hall and Whitfield. For their historic interest the original descriptions of Hall and the comments of Whitfield are given, as nearly as the advance of knowledge of the species will permit, in their original form.

All species described from this horizon, the "Warsaw" of Indiana, have been inserted here, so far as they have come to our notice. Those which have been studied are usually commented on except those represented in the original Hall collections, which have frequently been passed without comment.

No attempt has been made to determine the synonymy of species where no specimens of it were at hand for study.

Only the original description is mentioned in the bibliography of the species, as those of Weller, Schuchert and Nickles and Bassler cover the ground thoroughly and are available to all.

By force of circumstances and contrary to the usual custom, the chart showing the distribution and relative abundance of species will be given after the description of the fossils. Again, contrary to the usual custom, the discussion of the relationships of

this fauna to those of the subjacent and superjacent formations will be omitted until they have been more carefully studied and described.

The authors wish to express their obligations to the American Museum for the loan of specimens for comparison and study; to the National Museum for the loan of Bryozoa to compare with ours; to Mr. G. K. Greene for the loan of the Lanesville material in his collection and the valuable suggestions made; to Mr. R. S. Bassler, of the U. S. National Museum, for valuable suggestions in regard to the identification of several of the Bryozoa, and to the Indiana State Museum at Indianapolis for the loan of specimens.

Mention is due also to Messrs. L. C. Ward, A. W. Thompson, C. W. Shannon, T. E. Mason, C. T. Randolph and L. R. Gray, for valuable assistance in preparing and identifying material.

The drawings of this report were made by Miss Maud Siebenthal, of Bloomington, Indiana.

The authorship of the report is as follows:

Protozoa to Pentremites, J. W. Beede.

Paper on Pentremites Conoideus, Miss Essie A. Smith.

Echinoderma and Vermes, J. W. Beede.

Bryozoa, E. R. Cumings.

Brachiopoda and Pelecypoda, J. W. Beede.

Gastropoda to Crustacea, E. R. Cumings.

Vertebrates, Prof. E. B. Branson, Oberlin College, Oberlin, Ohio.

## FORAMINIFERA.

### ENDOTHYRA BAILEYI Hall.

Plate XXVI, figs. 34-36; Plate VII, fig. 1.

*Endothyra Baileyi* Hall, Trans. Albany Inst., IV, p. 34, 1856.

Specific Characters. A trifle more robust than *E. bowmani*.

"Shell depressed, orbicular, sub-equally convex above and below, smooth, margin rounded, indented by the septa; spire depressed, involved; last volution slightly oblique, consisting of eight loculi; aperture contracted. The general form of this fossil is depressed, globular, with the involutions deviating slightly from the same plane. Not infrequently, however, the spire ascends in greater or less degree, and one or more loculi become visible be-

yond the single volution. Sometimes seven loculi only are visible in the volutions. The surface is smooth under the ordinary magnifier, and the outline is indented at the septa."

Localities.—Lanesville, Paynters Hill, Spergen Hill, Bedford, Bloomington, Harrodsburg, Ellettsville and Stinesville. Found wherever the formation is typically developed.

## ANTHOZOA (CORALS).

### CYATHAXONIA VENUSTA Greene.

Plate XI, figs. 2-2a.

*Cyathaxonia compressa* Greene (non Thompson 1877), Cont. Ind.

Pal., Vol. I, Pt. II, p. 9, pl. IV, ff. 14-17, 1899.

*Cyathaxonia venusta* Greene, Ibid, Pt. XIX, p. 187, pl. LVI, ff. 10-14, 1904.

Specific Characters.—Very slender, small, compressed corallum, straight, with high columella.

Corallum small, slender, straight, compressed and nearly smooth. Calyx elliptical, deep, with smooth slender columella projecting in the base. Primary septa reaching the central columella, the secondary uniting with the primary just before the columella is reached. Septa 30 to 36 in number. The union of the primary and secondary septa is less apparent at the top of the corallum than in sections nearer the base. Epitheca smooth, but showing small growth varices and longitudinal ridges corresponding to the septa. Height 14 mm., diameter of the calyx 4.5 mm. + 3.5 mm.

Localities.—Lanesville, Paynters Hill, Spergen Hill.

### AMPLEXUS BLAIRI Miller.

Plate VIII, fig. 5.

*Amplexus Blairi* Miller (as figured by Keyes), Geol. Surv. Mo., IV, p. 108, pl. XXXIII, f. 1, 1894. Originally described by Miller, 17th Ann. Rep. Geol. Surv. Ind., p. 618, pl. I, f. 7, 1892.

Specific Characters.—Long, slender, tortuous corals, with strong, unevenly spaced tabulæ and stout short septa.

Corallum long, rather tortuous, rather slender, or nearly cylindrical. The tabulae are rather widely spaced and nearly flat or

slightly concave. Septa equal, about 30 in specimens 11 or 12 mm. in diameter, extending about .75 to 1 mm. toward the center. The epitheca is not shown on the specimen before me. Concerning the Missouri specimens Miller states: "The epithecal crust smooth and very strongly developed within the annulated depressions and much less distinct at the dilations." The "Annulations" referred to are probably strong growth varices. According to Miller the corallum "rapidly expands from a pointed base to the first dilation, where it bends abruptly upward."

Locality.—Edwardsville, Indiana. Specimen illustrated in the collection of Mr. G. K. Greene.

*ZAPHRENTIS CASSEDAYI* Milne-Edwards and Haime.

Plate VII. figs. 3-3c.

*Zaphrentis Cassedayi* Milne-Edwards and Haime, Hist. Nat. Corr. III, p. 341, pl. GI, f. 2, 1860.

*Zaphrentis prona* Milne-Edwards and Haime, Ibid., p. 342.

*Zaphrentis spergenesis* Worthen, Geol. Surv. Ill., VIII, p. 77, pl. X, f. 8-a, 1890.

*Zaphrentis cassedayi* Greene, Cont. Ind. Pal. I, pt. p.

Specific Characters.—Corallum small, long, slender, turbinate, spinous, with nearly circular cross section. Extremely deep calyx.

Corallum slender turbinate, attached or free, slightly arcuate to straight, sharply pointed (and frequently sharply bent) below. Calyx approximately circular, very deep; septa on its rim represented by low sharp lines, but extending to the center in the bottom of the calyx. Fossula large, deep and reaching to the center. At the margin of the calyx the primary and secondary septa are all of the same size, but are differentiated below; 44 to 48 in an adult specimen. Epitheca wrinkled and showing well defined longitudinal ridges corresponding with the interseptal spaces, the furrows marking the septa, which appear to split on joining the epitheca. Epitheca more or less thickly set with small spines, which point obliquely downward and appear in rows on the growth wrinkles. Sometimes these spines are almost wholly wanting.

Localities.—Lanesville, Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville and Romona.

*Zaphrentis prona* seems to have been described from a somewhat

arcuate specimen of this species without spines, while Worthen's figure represents a typical specimen of the species. Its small size and slender form will distinguish it from *Z. spinosa* of Hall. In external appearance it resembles, quite a little, *Lophophyllum profundum* M-E. and H., from the Coal Measures.

ZAPHRENTIS COMPRESSA Milne-Edwards and Haime.

Plate VII, figs. 4-4d.

*Zaphrentis compressa* Milne-Edwards and Haime, Hist. Nat. Corall., III, p. 342, pl. GI, ff. 3, 4, 1860.

*Zaphrentis lanceolatus* Worthen, Geol. Surv. Ill., VIII, p. 76, pl. X, ff. 4-4b, 1890.

Specific Characters.—Short, robust, compressed turbinate corallum, with about 20 to 24 primary septa in an average-sized individual.

Corallum straight or curved, turbinate compressed, pointed below. Calyx elliptical, rather deep, septa reaching about a third the way to the center at the top of the calyx and reaching to the fossula below. Fossula usually situated on the concave side of the corallum, deep, reaching to the center, around which the septa join. Primary septa 20 to 24. Secondary septa small but very distinct. Epitheca with faint longitudinal ridges when well preserved and faint growth lines.

Localities.—Spergen Hill, Paynters Hill, Lanesville.

ZAPHRENTIS CLINATUS Greene.

Plate XI, figs. 1-1c.

*Zaphrentis clinatus* Greene, Contr. Ind. Pal., Pt. XIX, p. 187, pl. 56, Figs. 6-9, 1904.

Original Description.—“Corallum simple, rather small, compressed, turbinate, regularly curved. Acute at the point of attachment. Height from 10 to 20 millimeters. Calyx oblique, from 10 to 15 millimeters in diameter. Depth 5 millimeters. A flat space in the bottom of the calyx, occupied by the tabulae 5 millimeters in diameter. Number of septa sixty-six in the circumference of a calyx, 20 millimeters in diameter, unequal in size at

the margin, alternating below, gradually sloping to the bottom of the calyx, where the short ones terminate, the longer ones continue to within 2 millimeters of the center of the calyx, and abruptly end, leaving a smooth, concave space 4 millimeters in diameter. Fossette consists of a deep depression in the center of the calyx and continues to the posterior margin. Exterior with moderately fine longitudinal striae, ten in the space of 5 millimeters. Surface comparatively smooth."

See *Z. compressa* M-E. and H. No specimens of this species have been examined.

#### BORDENIA Greene.

*Bordenia* Greene, Cont. Ind. Pal., I, pt. VII, p. 57, 1901.

"Corallum simple or composite, resembling *Zaphrentis*. Tabulae complete, with the central portion being smooth. Fossette well pronounced or scarcely more than rudimentary. Primary lamellae well defined. Secondary lamellae rudimentary or indicated by fine striae. Type B. *Zaphrentiformis*."

The fossils referred to this genus by Mr. Greene combine the characters to some extent of *Zaphrentis* and *Amplexus*. The regularity of the tabulae and the fact that the septa very rarely reach the center reminds one of *Amplexus*, while the fossula and the arrangement of the septa when they do reach the center, as they occasionally do, are well known characters of *Zaphrentis*. The genus *Bordenia* was erected to cover these combined characters, together with the character possessed by some of the specimens of calicular budding into a composite colony. Were it not for this latter character the specimens should be classed as an aberrant species of *Zaphrentis*.

#### BORDENIA ZAPHRENTIFORMIS Greene.

Plate VII, figs. 6-6c.

*Bordenia zaphrentiformis* Greene, Cont. Ind. Pal., I, pt. VII, p. 57, pl. XIX, ff. 2-9, 1901.

Corallum turbinate, robust, attached. Tabulae well developed, irregularly spaced and extending evenly across the corallum, turning down at the edges. Septa rather numerous, extending nearly

to the center, occasionally, but very rarely reaching it, frequently stopping at one-half to two-thirds the distance. There are 20 to 30 septa in adult individuals; secondary septa scarcely visible. There is no vesicular tissue in this species, but in cross section the turning down of the edges of the tabulae one above the other might be interpreted as such. The fossula is frequently hard to distinguish. The epitheca is well developed, with strong growth rings and rarely, slight longitudinal, rounded ridges, about two to the septum. The species increases by calicular budding into a composite colony.

Localities.—Lanesville, Paynters Hill, Spergen Hill.

The calicular budding, when present, and the presence of the fossula, when well developed, will at once distinguish this species from any other Carboniferous coral. From its general appearance it is more apt to be confounded with *Amplexus fragilis* or *A. blairi*, but the characters mentioned above and the longer septa will at once distinguish it.

#### ENALLOPHYLLUM Greene.

*Enallophyllum* Greene, Contr. Ind. Pal., pt. VII, p. 54, 1901.

"Corallum having tabulate area with vertical walls, resembling *Diphyphyllum*, and having a well developed fossette. Septa occur singly or in pairs, not extending farther than the vertical wall in the center of the calyx. Type *E. Grabaui*."

#### ENALLOPHYLLUM GRABAU I Greene.

Plate VII, figs. 2-2d.

*Enallyophyllum grabau i* Greene, Contr. Ind. Pal., VII, p. 54, pl. 20, Figs 8-18, 1901.

Original Description.—"Corallum simple, or composite, increasing by gemmation from the superior margin to the parent cup, turbinate, straight or slightly curved. Acute at the point of attachment. Some examples have a broad scar at the base, some corallums have root-like prolongations that served for attachment and support. Exterior, when well preserved, exhibits numerous fine spines, distributed without any regularity, and frequently extends some distance on the side of the coral. Height varying in different individuals from 10 to 20 millimeters, or more in some



examples. Calyx somewhat expanded, from 8 to 10 millimeters in diameter. Depth 7 or 8 millimeters, walls nearly vertical. Situated in the center of the calyx is a vertical wall occupying one-third or slightly more than the corallum at that point. The tabulae is smooth and strongly oblique, occupying the entire inner area. Number of lamellae (septa) 54, in the circumference of a calyx 7 millimeters in diameter. Equal in size, and somewhat rounded at the margin, occurring in pairs except the single one that marks the continuation of the fossette, and three single ones on the opposite side to the fossette. Sometimes these three lamellae coalesce, and in some examples where the cup is well preserved they are not united, the lamellae extends to the vertical wall in the center of the calyx and abruptly terminates. The fossette consists of a deep depression at the margin of the smooth, oblique space in the center of the calyx, and continues some distance on the side of the coral, the position of the fossette is variable. I have examples with the fossette on the anterior and others having it on the posterior side."

Locality.—Lanesville, Indiana. Collection of G. K. Greene.

This species can be best understood as a *Zaphrentis* so modified that the inner part of the fossula is greatly enlarged and evenly tabulated throughout the length of the individual, the fossula proper being located at the side of the calyx.

#### CYSTE LASMA Miller.

*Cystelasma* Miller, 17th Ann. Rep. Ind. Dept. Geol. and Nat. Res., p. 622, 1892.

"Corallum simple, irregularly turbinate or conical, consisting of an outer wall, transversely wrinkled or constricted, which is connected by oblique plates, irregularly disposed, that give to the interior cystose chambers of unequal size and irregular shape. No septa or regular tabulae. Structure vesicular. Type *C. lanesvillense*." To this diagnosis should be added the fact that some specimens show indications of rudimentary septa and some species show septa and others exhibit what appear to be rather regular tabulae.

## CYSTELASMA LANESVILLENSE Miller.

Plate VIII, figs. 3-3d; Plate XI, figs. 3-3f.

*Cystelasma lanesvillense* Miller, Adv. Sheets, 17th Ann. Rep. Ind. Dept. Geol. Nat. Res., p. 13, pl. I, Figs, 15, 16, 1891. 17th Ann. Rep. Ibid, p. 623, 1892.

"Corallum simple, small, subcylindrical, attached by rootlets or by a basal pedicel, strongly wrinkled and constricted transversely; sometimes expanding rapidly from a small basal pedicel to the full size of the corallum, \* \* \* or gradually expanding from rootlets. \* \* \* Internal structure consisting of large and small cystose chambers or cavities, without any regular order, the walls being longitudinal, transverse and oblique, sometimes leaving the whole internal diameter of the corallum in a single chamber, and again dividing into two, three, four or more cavities, some of which are much larger and much more elongated than the others. The cavities in our specimens are empty or filled with calcite. There is no calyx, for the summit is open or divided by internal walls, showing incomplete cavities, and the same structure that exists below. There are no septa or true tabulae."

Localities.—Lanesville, Spergen Hill and Paynters Hill.

There are occasionally rudimentary septa shown in the walls of this species and slight external vertical ridges in the epitheca. Rudimentary ridges sometimes show on the inner walls of the calyx of well preserved specimens. There are a great variety of forms of this species. It was attached by cementing or rootlets and the form seems to be governed largely by the nature and stability of the support. The form is also greatly modified by the tendency to regeneration by calicular budding, in which the bud replaces the parent corallite, frequently changing abruptly the direction of growth and giving it a very rough, constricted outline, as shown in the figures. There is a more slender form grading into this one which may have had a firmer basis of attachment and grew proportionately more tall and smooth. It may also have been modified by the rapid accumulation of sediment about it. It shows all the characteristics of the former, however, even to anastomosing to some extent when they come in contact. I suspect that this latter characteristic is common to all the species of the genus.

There are in some of the specimens of this species a few, two to five, nearly vertical walls, but they are usually confined to the particular cyst in which they occur, though sometimes two cysts may have them in nearly the same planes.

CYSTELASMA SEPTATUM Greene.

Plate VIII, figs. 2-2d.

*Cystelasma septata* Greene, Cont. Ind. Pal., I, pt. VII, p. 56, pl. XIX, ff. 10-19, 1901.

Specific Characters.—Four or five vertical septum-like walls dividing the corallum into as many compartments, which are again subdivided into small cysts by more or less horizontal diaphragms usually confined by the two adjacent walls.

Turbinate *Crystelasma*s, slender or robust, smooth or highly wrinkled attached corallites. There are five, sometimes less, vertical walls having all the characteristics of septa passing from the base to the top of the corallite, reaching the center and dividing the specimen into radial compartments, which are subdivided into small cysts by horizontal or diagonal diaphragms confined to the compartment in which they occur. These cysts are small and very numerous. The epitheca is much as in the preceding species. Rarely a specimen shows indications of septa (smaller than the five) continuing through several cysts, but these are very rare.

Localities.—Lanesville, Paynters Hill and Spergen Hill. Specimens from Lanesville loaned by Mr. G. K. Greene.

A single specimen of this species shows a few smaller septa and is figured plate 19 Fig. 15. This specimen approaches in some extent the specimens figured, but not described, by Ulrich\* under the names of *Cystelasma rugosum* and *C. quinqueseptatum*. I should not be surprised if very large amounts of material showed *C. septatum* and both of Ulrich's forms to be the same species.

\*U. S. Prof. Pap. 36, Plate 5, Figs. 12a-g. These specimens are neither described nor do they have the internal characters shown. They do not deserve recognition at all as described species and the writer is aware that he is violating the rules governing such cases in giving him credit for the name used to designate the following species.

## CYSTELASMA RUGOSUM Ulrich.

Plate VII, figs. 5-5b.

*Cystelasma rugosum* Ulrich, U. S. Prof. Pap. 36, p. 46, pl. V. ff. 12a-g, 1905.

Specific Character.—A *Cystelasma*, like *C. septatum*, but with 16 or 18 septa.

Corallum of average size for the genus, bluntly turbinate, attached and constricted. Septa 5 primary and 16 or 18 secondary extending through the larger part or all of the corallite. Epitheca with faint longitudinal striae ribs over septa. In all other respects it is like *C. septatum*, and may be a variation of it.

Locality.—Paynters Hill. Specimens figured belong to the Indiana University collection.

I can not be certain that this species is the same as the one figured but not described by Ulrich previously mentioned, but from general appearances there would seem to be no question as to their specific identity.

## CYSTELASMA TABULATUM n. sp.

Plate VIII, figs. 1-1c.

Specific Characters.—Five "septa" reaching a third the way to the center and tabulae reaching pretty evenly across the corallite.

Corallum of medium size, tortuous and constricted. Tabulae numerous, rather evenly spaced and nearly horizontal. Septa five, extending the entire length of the specimen and reaching about a third the way to the center. No other dissepimental tissue. Epitheca thin and, on the two specimens at hand, smooth except for the growth annulations. They probably possess finer markings, but are not preserved on our specimens.

Locality.—Spergen Hill. Types in the Indiana University Museum.

This species might be placed with *Amplexus* if its habit, appearance and associates were not considered. However, I am satisfied that it belongs to a distinct phylum. It has all the appearance of the *Cystelasma*s, with which it occurs, the five septa, common to all the species but one, and that one shows this structure

occasionally in single large cysts, which occupy the entire diameter of the corallum.

It seems to be most closely related to *C. lanesvillensis*, the diagonal walls of which have become horizontal and the five septum-like ridges, sometimes seen, developed into the five septa as seen in the types.

It may seem to be stretching a generic description somewhat to include in it species with both septa and tabulae when it expressly states that it contains neither. However, Ulrich has rightly pointed out that there are sometimes indications of rudimentary septa present in the type species. The tabulae in this species may be regarded as the dissepimental walls of the type species arranged more horizontally, some of which, even in *C. lanesvillensis* pass almost horizontally across the cavity of the body.

#### SYRINGOPORA MONROENSE n. sp.

Plate IX, figs. 1-2; Plate X, figs. 1-2; Plate XI, figs. 7-7f.

Specific Characters.—Absence of connecting bars, robust corallites budding rather indiscriminately above the base, thickened walls like *Monilopora*, but often having crowded tabulae, somewhat like *Syringopora*. Barely anastomosing when the thickly set corallites come in contact.

Corallum large, spreading, nearly flat on top, the base first spreading like *aulopora* until about the size of a small saucer and becoming very thick with corallites when they turn upward in a dense colony. The vertical tubes occasionally give off buds, sometimes two at the same level, but this is more or less accidental unless the growth of the colony is interfered with. In such cases the buds may be given off of most of the corallites at the same level. The colonies are frequently two inches in depth. The tubes are large for the genus, thickly set, but the circular nature of the calyx is never made angular by the contact of corallites. The interior of the tube is filled to a considerable extent below with secondary deposit from within. (The semi-silicified nature of these specimens is such that satisfactory thin sections can not be made of them.) In some tubes there are thickly set tabulae sagging in the middle, but not funnel-shaped as in typical *Syringoporas*. In other tubes there seem to be no tabulae whatever.

In one case vesicular tissue was seen in one of the tubes, which is represented on the plate of drawings.

Localities.—Lanesville (three specimens from State Museum), types from Bloomington, and in the Indiana University collection.

This species is intermediate in many of its characters between *Syringopora* and *Monilopora*. Its habit of growth and abundant concave tabulae (not present in all tubes) are characteristic of *Syringopora*. On the other hand, the absence of cross bars connecting the corallites, the deposition within the lower part of the tubes, and absence in some tubes of many tabulae are characters usually ascribed to *Monilopora*.

The characters which seem to separate this species from *Syringopora* will distinguish it from the species of that genus, while those separating it from *Monilopora* will equally distinguish it from the known species of that genus.

After a long discussion of the subject Girty\* concludes that the families of this group of corals need a thorough revision in the light of new material. I certainly agree with him in this respect. Meanwhile I think it best to refer material to already described genera instead of describing a new genus for each case arising and thus adding to the confusion.

#### MONILOPORA BEECHERI Grabau.

Plate XI, figs. 6-6a

*Monilopora beecheri* Grabau, Proc. Bost. Soc. Nat. Hist., XXVIII, p. 411, pl. I, ff. 2, 3, pl. II, ff. 1-5, 1899.—Cont. Ind. Pal. I, pt. VII, p. 50, pl. XIX, ff. 20, 21, 1901.

Original Description.—“Corallum regularly branching or forming a confused mass of intergrown tubes, which branch and repeatedly unite, the calices opening in all directions. Tubes expanding rapidly towards the calyx, below which they give off more lateral buds. Adjoining corallites frequently united by their walls. Walls thick, especially in the lower portion of the corallites, consisting of numerous concentric lamellae, between which the reticulate structure appears. The lacunæ are subequal, but the lamellae separating them are more irregular, and as a rule thicker

\*U. S. Prof. Pap. 16, p. 325, 1903.

than those of *M. crassa*. The trabeculae are also more irregularly disposed."

Localities.—Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville.

"This species differs from the described and figured forms of *M. crassa* in the larger size of its corallites, the more confused growth of the agglomerate mass, and the greater length and more regular budding of the simple branches. The internal differences appear to be the irregularities of the reticulate tissue, which also is much less frequently developed. From *M. antiqua* it differs chiefly in its surface features, and in the thickness of the wall, which in that species is stated to be 'rather thin.'"

"The regular coralla give off calices at definite intervals, these calices pointing upward and outward on all sides. From this it appears that the regular coralla grew upright, unsupported except basally. The more usual method of growth, however, seems to have been by irregular budding, which resulted from the attachment of the young coral to the crinoid stem. Such an attached individual would not require the regular growth, which is necessary in the free corallum to maintain proper balance, and hence the attached corallum put out buds promiscuously."

None of the attached colonies appear in our collection, probably for the reason that there was nothing of any considerable size to attach to; the conditions varying much from the crinoid beds at Crawfordsville, from which the types were taken. Some specimens, shown in the photographic plate,\* grew around some circular or cylindrical object, apparently too weak for support, so that instead of forming an attached mass it grew away again, leaving a row of calices growing directly away from the support. Our specimens agree very well with the figures and description of the free specimens from the type locality, show about the same amount of thickening of the lower portions of the tubes, but the reticulate tissue seems to be more sparingly developed. However, it occurs occasionally. The specimens from this horizon are either too coarsely silicified to show anything of the microscopic structure or are partially silicified, making sectioning in a satisfactory manner nearly impossible.

\*Since this was written the plate was discarded.

One point in which an occasional specimen differs from the types is shown on the halftone plate;\* that is, in showing a tendency to regeneration by calicular budding, the new bud replacing the old one and filling the old calyx. Sometimes these originate on or near one side and again seem to originate centrally.

CERATOPORA AGGLOMERATA Grabau.

Plate XI, figs. 5-5a.

*Ceratopora agglomerata* Grabau, Contr. Ind. Pal., Pt. VII, p. 51, pl. 19, figs. 22-25, 1901.

Original Description.—“Corallum compound, consisting of agglomerate masses, unattached except basally. Corallites auloporoïd, slightly curved, and gradually enlarging towards the aperture, which is circular. A short distance below the termination of the corallite one or two buds are given off, diverging at various angles; sometimes extending acutely upward; frequently at right angles to the parent, or occasionally extending downward. The buds themselves give off other buds, which may extend in all directions. Corallites frequently joined by epithecal prolongations. Interior with circumferential cysts. Cysts rather sparingly developed, but usually of fair size. Septal spines small, short and comparatively stout; in numerous vertical rows.

“This species is readily recognized by its singular branching corallites, which form a confusedly agglomerate mass. The frequent rectangular branching divergence of the buds from the parent gives rise to masses in which corallites of the third generation may grow in a diametrically opposite direction from that taken by the corallites of the first generation. Sometimes from crowding a bud may grow in such a direction as to form a complete loop with its parent corallite. Not infrequently a number of corallites, budding one from another, appear to form a ring around a corallite of an earlier generation, which occupies the center.

“No case has been observed where there are more than two buds given off at the same level, this being the usual number. In this respect the species is like *C. dichotoma* Grabau, but the buds are irregular, as in *C. distorta*, Grabau. In some corallites, however, a second series of buds are given off at a higher level, and these, rebudding again, greatly increase the complexity of the whole

\*Since this was written the plate has been discarded.



corallum. In some cases, however, the corallites grow to a considerable length after giving off their first pair of buds, without producing a second series. While the buds are most frequently given off in pairs, the two are not always given off at precisely the same level, there being often a slight discrepancy between them. This feature is occasionally seen in *C. dichotoma*, the most regular species of the genus, and is common in *C. distorta*.

"When the corallites are united by the epithecal prolongations, a rugose surface is produced from the wrinkled character of the epitheca. Otherwise the surface is smooth, showing only fine concentric growth lines. When the corallites grow close together they generally become inseparably united, and not infrequently the original circular section of the tube will be variously modified or distorted, and often become concave on the side of contact.

"The less frequent development in this species of the cyst is a characteristic feature. They are best visible in the calicinal portions, for as the known specimens of this species are all silicified, the interior structure has become more or less modified, and some of the cysts have been filled. There is, as in all the species of the genus, a complete absence of tabulae, the corallites remaining open throughout and united to their parent basally at least during the greater part of life. In many individuals the connecting pore is probably never closed, in others a sort of partition is formed over it by the extensive growth of spines. When the daughter corallite becomes separated from the mother tube the pore may be covered by the formation of a cyst wall over it. Occasionally adjoining corallites have been found to be traversed by a single pore, this undoubtedly being a case of aborted budding. The septal spines appear generally much shorter than in the Devonian species in this respect, and in the diminution of the cysts, approaching *Monilopora*. In a few cases, however, spines comparable to those of *C. dichotoma* and *C. distorta* have been observed. In some cases the interior of the wall appears perfectly smooth, the fine papillose spines being probably destroyed during the process of crystallization.

"This species is closely related to *C. distorta* Grabau, but I do not think that the two are identical. The profusely branching specimen figured on plate 3, Fig. 7, Vol. 28, Sp. 16, Boston Soc. Nat. Hist. Proceedings, and referred to *C. distorta*, has many char-

acters of the present species, and forms a connecting link between the two. Though parallelisms in form occur, the structure of the two species is sufficiently distinct. The present species is also somewhat smaller than the prevailing forms of *C. distorta*."

Horizon and Localities.—"In the Warsaw Division of the St. Louis Group, Lower Carbonian; Lanesville, Harrison County, Indiana."

#### PROTOPORA Greene.

*Protopora* Greene, Cont., Ind. Pal., pt. XVII, p. 169, 1904.

"Corallum composite, increasing by lateral and calicular gemination. Corallites frequently connected by their epithecal walls, and having numerous transverse and oblique diaphragms which divide the tubes into coarse cysts somewhat like *Cystelasma*, but differing from *Cystelasma* in having mural pores in the adjoining corallites as in *Romingeria*. Type *P. Cystoides*."

Grabau states concerning *Romingeria cystoides*: "These diaphragms, together with the absence of septal spines, and general rugose corallum, separate this species from the others of the genus, and may make it desirable to place it in a distinct genus. These features closely ally the present species to *Cystelasma*, S. A. Miller, of which the type *C. Lanesvillense* occurs in the Warsaw group of Indiana. This genus, however, is stated to be simple, while the present species has the compound mode of growth and mural pores of *Romingeria*. Under this genus it will be left for the present, until better preserved material allows the making of sections for the closer study of the internal structure."

#### PROTOPORA CYSTOIDES (Grabau).

Plate XI, 4-4d.

*Romingeria cystoides* Grabau, Cont. Ind. Pal., I, pt. VII, p. 52, pl. XX, ff. 19-23, 1901.

*Protopora cystoides* Greene, Contr. Ind. Pal., I, pt. XVII, p. 169, 1904.

"Corallum compound, erect, free except basally, consisting of numerous more or less closely crowded corallites, which usually proceed in an unbelliferous manner from the parent corallite. Corallites elongate-conical to sub-cylindrical, widening at first rapidly,

then more slowly, and finally retaining almost the same diameter throughout. Calicinal portion not infrequently inflated.

"Corallites closely adnate for the greater part of their length, and connected by mural pores. Septa absent so far as known. Interior traversed by irregular lamellae, which extend across the cavity and frequently join each other, dividing the visceral chamber into a number of cysts."

Locality.—Lanesville.

"This species is readily recognized by its rather coarse though not large corallites, the mural pores and the irregular diaphragms which take the place of tabulae. The corallites bud off from the parent in verticils of three or more, and they grow upward, closely adhering to the old corallites, which also continue to grow and to embrace each other. They are closely united by the epitheca, which in some cases extends across several corallites, and in others effects the junctions merely by root-like proliferations. The epitheca is wrinkled and the growth lines are strong, and this, with the frequent constrictions of the corallites, gives them a very rough and wrinkled appearance. The direction of growth is upward in most cases, but in some colonies it is more irregular, the corallites growing loosely. In such cases the unbelliferous habit is generally lost sight of."

The drawings, plate XI, Figs. 4, 4a, were made from specimens loaned by Mr. G. K. Greené, who has the types, and whose identification of these specimens is used.

*MICHELINIA INDIANENSIS* n. sp.

Plate XI, figs. 8-8a.

Specific Characters.—Conical or taller habit, very small corallites, with large number of young or undersized ones, thin walls.

Corallum irregularly conical, small, base unknown. Corallites small, very deep and many angled like *Favosites*, and varying in size with age. The largest corallites are  $2\frac{1}{4}$  mm. in diameter. There are about two small corallites to one well developed one. The walls are very thin and the edges of the corallites proportionately sharp. The mural pores are fairly abundant and large, the scale-like tabulae frequently developed as little awnings over the pores, though in the older part of the corallite they occur inde-

pendent of the pores and are very numerous. There are six to eight corallites per centimeter.

Locality.—Lanesville. Type specimens in the collection of G. K. Greene.

This species is very closely allied with what Ulrich has figured but not described as *M. eugeneae* var *princetonensis* from a higher horizon. However, he has not described his "variety," and our specimens differ from his figures in having thin walls instead of thick ones and in being a much more delicate colony with smaller cells and a larger percentage of immature ones. These characters will at once separate it from *M. eugeneae* and probably from Ulrich's variety.

PALÆACIS CUNEIFORMIS Milne-Edwards and Halme.

Plate VIII, figs 4-4i.

Specific Characters.—Cuneate corallum with corallites all in one plane, with crenulated surface marks.

Corallum cuneiform, key-shaped, free, higher than wide and rather sharp below, rounded at the edges. Sometimes, however, the base may be rather blunt and taper nearly to a point. The form of the specimens of this species is very variable. The specimens thicken and expand laterally until the region of the corallites is reached, when they rapidly contract, making the specimen paddle-shaped or key-shaped. The calices are large, long-elliptical to nearly circular and fairly deep. They are two to five, depending on the age of the corallum, alternately spaced, extending obliquely inward and downward. When first developed each calyx is placed a little to one side of the middle of the corallum. The inner surface of the calices is coarsely punctuate, the punctae, being located in slight depressions, produce a slightly pustular surface. There is also a faint ridge passing up the inner or back side of the cavity. The ridges forming the surface markings of the specimen, terminating at the margins of the openings, give them a crenulated periphery. The surface ornamentation consists of wavy ridges closely set and minutely crenulated, extending obliquely inward and downward.

Localities.—Spergen Hill, Paynters Hill.

## DEVELOPMENT AND VARIATION OF PENTREMITES CONOIDEUS.

BY ESSIE ALMA SMITH.

Up to the present time very little has been done toward the study of the development of *Pentremites*, and until recently there had not been any very comprehensive study of the anatomy of the Blastoid group. Perhaps one reason for this neglect is the fact that there are no living representatives of this group, and a study of it must necessarily be difficult, because such a study must be based entirely upon the fossil specimens. Prof. G. Hambach, of Washington University, has given a series of drawings\* showing the development of the deltoid pieces in *Pentremites sulcatus*.

The present writer has attempted to make a study of the development and variation of *Pentremites conoideus*, and from this study and a comparison of the young of *P. conoideus* with *Codaster* sp. from the Hamilton formation there has been found at least a hint as to the possible ancestry of *Pentremites*. Another point which this study has incidentally brought out is a suggestion as to the possible cause of the dwarfing of the fauna of the Salem limestone. The writer has also discovered specimens in the series studied which seem to prove that there are plates or septa in the oral opening of *P. conoideus*.

The material used in this investigation includes more than 5,700 specimens. About 980 specimens are in the Indiana University Geological Museum, 354 specimens belong to the State Museum, and Mr. G. K. Greene has kindly loaned about 4,400 specimens from his fine collection.

The specimens used in the investigation came from the Lower Carboniferous series, and from eight localities, as follows: Four thousand seven hundred specimens from Lanesville, Ind. (Salem limestone); over 276 specimens from the old Cleveland quarry, near Harrodsburg, Ind. (upper part of Salem limestone); 240

\*"A Revision of the Blastoideae." Trans. Acad. Sci. of St. Louis. Vol. xiii, Plate vi.

specimens from Pentremite Hollow, south of Bloomington, Ind. (upper part of the Harrodsburg limestone); 165 specimens from Spergen Hill, Ind. (Salem limestone); 150 specimens from Paynter's Hill, Ind. (Salem limestone); 48 specimens from the Big Creek quarries, near Stinesville, Ind. (Salem limestone); 40 specimens from Hunter Valley, northwest of Bloomington, Ind. (Salem limestone); and over 40 specimens from the Matthews quarry, Ellettsville, Ind. (Salem limestone.)

The study is based upon the measurement of 735 specimens, upon the microscopic examination of over a dozen small specimens, the distal ends of which had not been preserved, and upon the careful examination of the rest of the material. The 735 specimens which were measured and the small specimens which were microscopically examined, are in the Indiana University Geological Museum.

The writer takes this opportunity to express her thanks to Mr. G. K. Greene for the specimens which he kindly loaned, and to Dr. E. R. Cumings for the accompanying photographs. During the prosecution of this study the writer has received much encouragement and many valuable suggestions from Drs. E. R. Cumings and J. W. Beede. For this encouragement and these suggestions the author is deeply grateful.

A great deal of the material in the University Geological Museum, especially that from Harrodsburg and Pentremite Hollow, was collected in a manner which almost entirely eliminates the personal equation. The collector shoveled up the material just as it had been weathered from the rock. It was brought into the laboratory, where it was washed through three sieves, each having a different sized mesh. Three grades of material—coarse, medium and fine—were thus obtained. This material was then carefully looked over with the aid of a reading glass and lens, and all of the Pentremites seen were picked out for study. Of the specimens which were measured, those from Harrodsburg and from Pentremite Hollow have been of the most value and interest in this study, first, because the series from these localities are more complete, and, second, because the specimens from Harrodsburg are dwarfed and those from Pentremite Hollow are normal. For this latter reason they lend themselves admirably to the study of the dwarfing of the fauna of the Salem limestone.

The method of investigation consisted in counting the number of poral pieces in each of the 735 specimens, in making certain careful measurements of these specimens, and in a general study of all of the material. The smallest specimens used in this investigation contained no poral pieces. The distal portion had not been preserved and the writer is doubtful if some of the smallest of these specimens ever possessed poral pieces.

The measurements taken in addition to counting the number of poral pieces, were, first, the relative length of the ambulacral area (a) (See Fig. 1), and the radius of the base (b), and the ratio of the length of the ambulacral area to the radius of the base; second, the measurement of the angle (c), formed by the

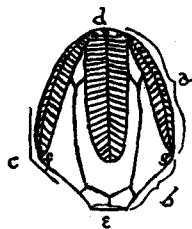


Fig. 1.

junction of the ambulacral area and the base; third, the length of the entire specimen, from (d) to (e); and fourth, the breadth of the specimen from (f) to (g). The ratio of length to breadth was obtained by dividing the length by the breadth. All measurements were made with a millimeter scale, with the exception of the angle measurement, which was made with a contact goniometer.

The data thus obtained have been arranged by localities. They have been further arranged according to the number of poral pieces. The original data, being somewhat lengthy, have been shortened by averaging all of the measurements of specimens having the same number of poral pieces. Below are given the data:

## HARRODSBURG—CLEVELAND QUARRY.

Number of Specimens.	Number of Portal Pieces.	Relative Length of Ambulacral Area.*		Angle Between Ambulacral Area and Base.	Length.	Breadth.	Ratio of Length to Breadth.
5	3	.62 + : 1.91 + mm	.37 +	109°	2.22 + mm	1.73 mm	1.28 +
19	4	.93 + : 1.86 + mm	.49 +	111°	2.52 + mm	2.16 mm	1.16 +
11	5	1.06 + : 1.84 + mm	.57 +	115°	2.74 + mm	2.23 + mm	1.22 +
15	6	1.46 + : 2.31 + mm	.63 +	114°	3.26 + mm	2.75 mm	1.18 +
21	7	1.78 + : 2.42 + mm	.73 +	116°	3.52 + mm	3.01 + mm	1.16 +
16	8	2.04 + : 2.43 + mm	.83 +	116°	3.75 mm	3.25 mm	1.15 +
12	9	2.33 + : 2.55 + mm	.91 +	118°	4.08 + mm	3.35 + mm	1.21 +
18	10	2.51 + : 2.78 + mm	.90 +	118°	4.46 + mm	3.58 + mm	1.24 +
16	11	2.76 + : 2.68 + mm	1.02	117°	4.62 + mm	3.78 + mm	1.22 +
15	12	3.00 + : 2.76 + mm	1.08 +	118°	4.96 + mm	3.95 + mm	1.23 +
13	13	3.38 + : 2.91 + mm	1.16 +	118°	5.32 + mm	4.18 + mm	1.27 +
20	14	3.70 : 2.88 + mm	1.28 +	118°	5.60 mm	4.43 + mm	1.26 +
15	15	3.81 + : 2.93 + mm	1.30 +	115°	5.71 + mm	4.56 + mm	1.25 +
16	16	4.34 + : 3.32 mm	1.30 +	117°	6.15 + mm	4.84 mm	1.27 +
9	17	4.66 : 3.17 + mm	1.47	116°	6.38 + mm	5.11 mm	1.24 +
5	18	4.60 : 3.17 mm	1.45 +	119°	6.45 mm	5.05 mm	1.27 +
8	19	5.14 : 3.31 + mm	1.55 +	116°	6.87 + mm	5.34 + mm	1.28 +
10	20	5.60 : 3.55 mm	1.57 +	116°	7.37 + mm	5.54 + mm	1.33 +
5	21	5.76 + : 3.36 + mm	1.71 +	115°	7.23 + mm	5.55 mm	1.39 +
9	22	6.20 + : 3.66 + mm	1.69 +	116°	8.25 + mm	6.11 mm	1.35 +
3	23	6.75 : 3.66 + mm	1.81 +	113°	8.22 mm	6.50 mm	1.26 +
3	24	7.11 : 4.16 + mm	1.73 +	119°	9.28 mm	6.83 + mm	1.35 +
4	25	7.25 : 3.81 + mm	1.90 +	115°	8.87 + mm	6.41 + mm	1.38 +
1	26	8.00 : 4.50 mm	1.77 +	120°	10.50 mm	7.50 mm	1.40
3	28	8.00 : 4.00 mm	2.00	113°	9.66 + mm	7.00 mm	1.38
2	29	9.50 : 4.50 mm	2.11	113°	12.00 mm	7.50 mm	1.60
1	31	10.50 : 5.00 mm	2.10	110°	12.00 mm	8.00 mm	1.50
1	34	11.00 : 4.50 mm	2.44 +	108°	11.50 mm	8.50 mm	1.35 +

\*The first column of numbers under this heading represents the absolute length of the ambulacral area; the second column represents the absolute length of the radius of the base; and the third column is the result obtained by dividing the figures in the first by those in the second column.



## BLOOMINGTON--PENTREMITE HOLLOW.

Number of Specimens.	Number of Fossil Pieces.	Relative Length of Ambulacral Area.*				Angle Between Ambulacral Area and Base.	Length.		Breadth.		Ratio of Length to Breadth.
1	8	2.00	: 2.50	mm	.80	112°	4.00	mm	3.50	mm	1.14
1	10	2.50	: 3.00	mm	.83 +	114°	4.00	mm	4.00	mm	1.00
2	11	2.75	: 3.00	mm	.91 +	117°	4.75	mm	4.00	mm	1.18 +
4	12	3.18	: 3.06 +	mm	1.03 +	115°	5.00	mm	4.25	mm	1.17 +
3	13	3.36 +	: 3.00	mm	1.12	115°	5.44 +	mm	4.72	mm	1.15 +
4	15	4.25	: 3.25	mm	1.30 +	113°	6.00	mm	5.00	mm	1.20
1	16	4.50	: 3.50	mm	1.28	98°	5.00	mm	6.00	mm	.83
4	17	5.25	: 3.91 +	mm	1.34 +	113°	6.81 +	mm	5.79	mm	1.17 +
5	18	5.10	: 3.35	mm	1.52 +	115°	6.93	mm	5.80	mm	1.19 +
8	19	5.59 +	: 3.65 +	mm	1.53 +	110°	6.87 +	mm	6.03 +	mm	1.13 +
6	20	5.86	: 3.83 +	mm	1.53	111°	7.30 +	mm	6.30 +	mm	1.15 +
8	21	6.25	: 3.84 +	mm	1.63 +	110°	7.58 +	mm	5.81 +	mm	1.30 +
7	22	6.73 +	: 4.07 +	mm	1.65 +	112°	8.02 +	mm	7.04 +	mm	1.13 +
10	23	6.92 +	: 4.12 +	mm	1.67 +	111°	8.01 +	mm	6.92	mm	1.30 +
6	24	7.20 +	: 3.91 +	mm	1.81 +	108°	8.52 +	mm	7.16 +	mm	1.18 +
4	25	7.12 +	: 4.00	mm	1.78	109°	8.25	mm	7.00	mm	1.17 +
8	26	8.31 +	: 4.56 +	mm	1.82 +	108°	9.27	mm	7.93 +	mm	1.16 +
5	27	8.25	: 5.00	mm	1.61 +	110°	9.20	mm	7.93 +	mm	1.15 +
4	28	8.66 +	: 4.75	mm	1.82 +	108°	9.87 +	mm	8.50	mm	1.16 +
6	29	8.52 +	: 4.75	mm	1.79 +	109°	9.66 +	mm	8.00	mm	1.20 +
10	30	9.01 +	: 4.67 +	mm	1.95 +	102°	9.56 +	mm	7.71 +	mm	1.23 +
7	31	9.64	: 5.00	mm	1.92 +	104°	10.25	mm	9.03 +	mm	1.13 +
10	32	9.70	: 4.97 +	mm	1.95 +	105°	10.20	mm	8.85	mm	1.15 +
8	33	10.50	: 5.14 +	mm	2.04 +	104°	10.85 +	mm	8.12 +	mm	1.33 +
5	34	10.60	: 5.50	mm	1.92 +	106°	11.50	mm	9.80	mm	1.17 +
11	35	11.11 +	: 5.54 +	mm	2.00 +	104°	11.63 +	mm	9.77 +	mm	1.19 +
10	36	11.70	: 5.45	mm	2.14 +	104°	11.85	mm	10.25	mm	1.15 +
4	37	12.06 +	: 5.68 +	mm	2.12 +	108°	12.87 +	mm	10.25	mm	1.25 +
10	38	12.45	: 5.95	mm	2.09 +	105°	12.90	mm	10.81 +	mm	1.19 +
6	39	12.75	: 5.83 +	mm	2.18 +	105°	13.08 +	mm	10.20 +	mm	1.18 +
12	40	12.58 +	: 6.25	mm	2.01 +	107°	13.75	mm	10.87 +	mm	1.26 +
5	41	13.75	: 6.63 +	mm	2.07 +	103°	13.90	mm	12.10	mm	1.14 +
5	42	14.00	: 6.70	mm	2.08 +	107°	14.70	mm	11.90	mm	1.23 +
4	43	14.00	: 6.50	mm	2.15 +	103°	14.12 +	mm	11.75	mm	1.20 +
6	44	15.25	: 6.25	mm	2.44	104°	15.16 +	mm	11.91 +	mm	1.28 +
9	45	15.66 +	: 6.77 +	mm	2.31 +	106°	15.61 +	mm	12.50	mm	1.24 +

\*See preceding footnote.

## BLOOMINGTON—PENTREMITE HOLLOW—Continued.

Number of Specimens.	Number of Poral Pieces.	Relative Length of Ambulacral Area.*		Angle Between Ambulacral Area and Base.	Length.	Breadth.		Ratio of Length to Breadth.
2	46	16.00	: 6.50 mm	2.46 +	101°	16.00 mm	12.00 mm	1.33 +
2	48	16.00	: 7.00 mm	2.28 +	106°	15.75 mm	11.50 mm	1.36 +
3	49	16.66 +	: 6.83 + mm	2.41 +	103°	17.16 + mm	12.50 mm	1.37 +
6	50	17.19 +	: 7.08 + mm	2.42 +	104°	17.22 + mm	13.20 + mm	1.38 +
3	52	17.66 +	: 6.66 + mm	2.65 +	103°	17.40 mm	12.00 mm	1.45
2	56	18.50	: 7.00 mm	2.64 +	98°	17.00 mm	13.25 mm	1.28 +
1	58	21.00	: 7.00 mm	3.00	104°	20.00 mm	14.00 mm	1.42 +
1	59	21.00	: 8.00 mm	2.62 +	104°	21.00 mm	15.00 mm	1.40
1	63	23.00	: 8.00 mm	2.87 +	101°	22.00 mm	16.00 mm	1.36

## SPERGEN HILL.

1	6	1.50	: 2.33 mm	.64 +	112°	3.33 mm	3.00 mm	1.11
2	7	1.75	: 2.37 + mm	.73 +	114°	3.58 mm	3.12 + mm	1.14 +
1	8	2.00	: 2.25 mm	.88 +	115°	3.50 mm	3.00 mm	1.16 +
1	9	2.00	: 2.25 mm	.88 +	115°	3.50 mm	3.00 mm	1.16 +
1	10	2.50	: 2.50 mm	1.00	117°	4.33 mm	3.50 mm	1.23 +
1	11	3.00	: 3.00 mm	1.00	118°	5.00 mm	4.00 mm	1.25
4	12	3.12 +	: 2.93 + mm	1.06 +	119°	5.16 + mm	4.00 mm	1.29
2	13	3.75	: 3.50 mm	1.07	120°	6.00 mm	4.75 mm	1.26 +
6	14	3.90 +	: 3.00 mm	1.30	117°	5.45 mm	4.54 + mm	1.17 +
4	15	4.31 +	: 3.12 + mm	1.38 +	120°	6.18 + mm	4.81 + mm	1.49 +
7	16	4.52 +	: 3.47 + mm	1.31 +	109°	6.05 + mm	5.48 + mm	1.10 +
10	17	4.94 +	: 3.32 + mm	1.48 +	112°	6.28 + mm	5.38 + mm	1.16 +
6	18	5.23 +	: 3.46 + mm	1.51 +	112°	6.70 + mm	5.56 + mm	1.20 +
5	19	5.40	: 3.75 mm	1.44	114°	7.23 mm	5.95 mm	1.22 +
11	20	5.83 +	: 3.81 + mm	1.53 +	110°	7.07 + mm	6.29 + mm	1.12 +
12	21	6.01 +	: 3.64 + mm	1.65 +	110°	7.22 + mm	6.27 + mm	1.15 +
6	22	6.16 +	: 3.45 + mm	1.78 +	112°	7.50 mm	6.02 + mm	1.22 +
16	23	6.51	: 3.78 + mm	1.72 +	109°	7.80 mm	6.79 + mm	1.14 +
8	24	6.93 +	: 3.81 + mm	1.81 +	103°	7.81 + mm	6.65 + mm	1.17 +
5	25	7.20	: 3.75 mm	1.92	108°	8.26 mm	7.10 mm	1.16 +
1	26	7.00	: 4.00 mm	1.75	102°	9.00 mm	7.50 mm	1.20
2	27	7.50	: 4.50 mm	1.66 +	107°	8.37 + mm	7.75 mm	1.08 +

\*See preceding footnote.

## STINESVILLE—BIG CREEK QUARRY.

Number of Specimens.	Number of Poral Pieces.	Relative Length of Ambulacral Area.*			Angle Between Ambulacral Area and Base.	Length.	Breadth.	Ratio of Length to Breadth.
1	5	1.25	: 2.25	mm .55 +	113°	3.00 mm	2.25 mm	1.33 +
1	6	1.50	: 2.25	mm .66 +	121°	3.00 mm	2.33 mm	1.28 +
4	7	1.68 +	: 2.18 +	mm .77 +	116°	3.18 mm	2.55 mm	1.24 +
5	8	2.00	: 2.43 +	mm .81 +	113°	3.70 mm	3.13 + mm	1.18 +
3	9	2.46	: 2.66 +	mm .92 +	119°	4.00 mm	3.22 mm	1.24 +
4	10	2.47 +	: 2.62 +	mm .94 +	120°	4.12 + mm	3.31 + mm	1.24 +
2	11	2.50	: 2.25	mm 1.11 +	118°	4.00 mm	3.37 + mm	1.18 +
3	12	3.00	: 2.91 +	mm 1.03 +	121°	5.00 mm	4.00 mm	1.25
2	13	3.16 +	: 2.75	mm 1.14 +	116°	5.16 + mm	4.20 mm	1.22 +
3	14	3.58 +	: 2.83 +	mm 1.26 +	114°	5.16 + mm	4.41 mm	1.17 +
1	15	3.75	: 2.50	mm 1.50	115°	5.00 mm	4.00 mm	1.25
4	16	4.06 +	: 3.00	mm 1.35 +	118°	5.75 mm	4.43 + mm	1.29 +
3	17	4.75	: 3.16 +	mm 1.50	119°	6.50 mm	5.33 + mm	1.21 +
1	18	4.50	: 3.00	mm 1.50	116°	5.50 mm	5.00 mm	1.10
3	19	5.11	: 3.72	mm 1.37 +	117°	7.11 mm	5.83 mm	1.21 +
1	20	5.00	: 3.25	mm 1.45 +	113°	6.66 mm	5.50 mm	1.21 +
1	21	6.00	: 3.50	mm 1.70	118°	7.50 mm	6.00 mm	1.25
1	22	6.00	: 3.50	mm 1.70	117°	7.50 mm	6.00 mm	1.25
1	24	7.00	: 3.50	mm 2.00	120°	8.00 mm	7.00 mm	1.14 +
1	27	7.50	: 3.25	mm 2.00	119°	10.00 mm	8.00 mm	1.25
1	30	8.00	: 3.50	mm 2.28 +	114°	9.50 mm	6.50 mm	1.46 +
1	32	11.00	: 6.00	mm 1.83 +	113°	12.50 mm	9.50 mm	1.31 +
1	33	11.00	: 6.00	mm 1.83 +	116°	12.00 mm	9.25 mm	1.28 +

## BLOOMINGTON—HUNTER VALLEY.

2	6	1.75	: 2.28 mm	.75 +	113°	3.16 + mm	2.87 + mm	1.10 +
1	7	2.00	: 2.50 mm	.80	116°	4.00 mm	3.00 mm	1.33 +
2	8	2.00	: 2.50 mm	.83 +	119°	4.00 mm	3.25 mm	1.26 +
1	9	2.50	: 3.00 mm	1.20	115°	4.50 mm	3.50 mm	1.28 +
2	10	3.00	: 2.50 mm	1.20	112°	4.50 mm	4.00 mm	1.12 +
1	11	3.00	: 2.75 mm	1.16 +	118°	5.00 mm	4.00 mm	1.25
2	12	3.40	: 3.40 mm	1.00	117°	5.50 mm	4.50 mm	1.22 +
5	13	3.25	: 2.70 mm	1.20 +	118°	5.25 mm	4.16 + mm	1.26 +
1	14	4.00	: 2.50 mm	1.60	113°	5.33 mm	4.66 mm	1.14 +
1	15	6.00	: 4.00 mm	1.50	116°	7.50 mm	5.00 mm	1.50
1	16	5.50	: 3.00 mm	1.83 +	117°	6.00 mm	5.00 mm	1.20

\*See preceding footnote.

## BLOOMINGTON—HUNTER VALLEY—Continued.

Number of Specimens.	Number of Pieces.	Relative Length of Ambulacral Area.*		Angle Between Ambulacral Area and Base.	Length.	Breadth.	Ratio of Length to Breadth.	
3	18	5.66 +	: 3.83 + mm	1.47 +	121°	7.66 + mm	5.83 + mm	1.31 +
1	19	5.50	: 4.00 mm	1.37 +	116°	7.00 mm	6.00 mm	1.16 +
2	20	5.75	: 3.25 mm	1.77 +	115°	7.00 mm	5.50 mm	1.27 +
1	22	7.50	: 4.00 mm	1.87 +	117°	9.00 mm	6.00 mm	1.23 +
1	23	7.00	: 3.50 mm	2.00	124°	8.00 mm	4.00 mm	2.00
1	24	7.00	: 3.50 mm	2.00	121°	8.50 mm	5.50 mm	1.54 +
1	25	8.00	: 4.00 mm	2.00	120°	9.50 mm	6.50 mm	1.46 +
1	26	8.00	: 4.00 mm	2.00	112°	8.00 mm	7.50 mm	1.06 +
1	27	8.00	: 4.00 mm	2.00	117°	10.50 mm	7.50 mm	1.40
1	33	10.50	: 5.50 mm	1.99 +	116°	12.00 mm	8.00 mm	1.50
1	34	11.00	: 5.50 mm	2.00	117°	14.50 mm	8.00 mm	1.81 +
1	35	11.00	: 5.50 mm	2.00	115°	14.00 mm	10.00 mm	1.40
2	40	16.50	: 8.50 mm	1.99 +	111°	16.50 mm	14.50 mm	1.13 +
1	43	15.00	: 7.00 mm	2.14 +	107°	15.50 mm	14.00 mm	1.10 +
1	45	15.00	: 6.00 mm	2.50	110°	15.00 mm	12.00 mm	1.25

## ELLETTSVILLE—MATTHEWS' QUARRY.

1	13	3.33	: 3.33 mm	1.00	125°	5.33 mm	4.25 mm	1.25 +
1	15	4.33	: 3.33 mm	1.30 +	122°	6.33 mm	5.33 mm	1.18 +
1	16	4.66	: 3.33 mm	1.39 +	119°	6.50 mm	5.25 mm	1.23 +
1	19	5.50	: 3.50 mm	1.56 +	119°	7.20 mm	5.50 mm	1.30 +
1	22	6.00	: 3.50 mm	1.71 +	120°	8.00 mm	6.33 mm	1.26 +
2	25	7.75	: 3.75 mm	2.06 +	113°	9.00 mm	7.25 mm	1.23 +
2	26	9.08	: 4.50 mm	2.01 +	115°	10.50 mm	8.12 + mm	1.29 +
1	27	8.50	: 4.50 mm	1.88 +	117°	9.66 mm	7.50 mm	1.28 +
2	28	9.75	: 4.50 mm	2.16 +	115°	10.75 mm	7.44 + mm	1.44 +
1	29	9.50	: 4.25 mm	2.23 +	115°	11.00 mm	8.00 mm	1.37 +
2	31	9.25	: 4.50 mm	2.06 +	112°	10.16 + mm	8.00 mm	1.27 +
1	32	10.00	: 5.00 mm	2.00	108°	11.00 mm	9.50 mm	1.15 +
2	33	10.75	: 5.25 mm	2.04 +	107°	12.00 mm	9.50 mm	1.26 +
1	37	11.50	: 5.50 mm	2.09 +	101°	11.50 mm	9.50 mm	1.21 +
2	41	14.50	: 7.00 mm	2.07 +	108°	14.50 mm	11.92 mm	1.21 +

\*See preceding footnote.

In studying the data the writer has gone carefully over each of the series of measurements and ascertained the number of specimens having a given measurement. The variates were then grouped into classes of convenient size and variation curves were plotted. This was done in order to get an idea of the ranges and modes of these different characters. The data from each locality were first considered in this way, and then the entire group of data, that is, the data for all the different localities were considered as a whole. The curves obtained in this manner give an idea of the developmental variations, but the element of specific variation also enters to a certain extent. In order to get a better idea of the specific variation another study of the data has been made. The data were considered by localities as before, but in this case there was a grouping of the specimens which were of approximately the same age. The number of poral pieces was taken as the criterion to determine the age. For instance, all specimens having from 8-12 poral pieces were considered in one group and all the different characters for this group were studied, and the ranges and modes of these characters were ascertained. This study was continued through the whole series, each group having a range of about 4 poral pieces. This grouping was done in order to eliminate the developmental element.

In Plates XLIII and XLIV are given the variation curves thus obtained from the Harrodsburg material. The curves on these plates give an idea of the general results of this study, therefore it is not thought necessary to take the space to give the curves for the other localities. However, the data which have been obtained from this study are given below. First are given the results of the study of the data for each locality, and the study of the data for all localities, showing the developmental variation; then the results of the study of the grouped data from Harrodsburg, Pentremite Hollow, and Spergen Hill, showing the specific variation.

	Poral Pieces.		Relative Length of Ambulacral Area.		Angle Between Ambulacral Area and Base.		Length.		Breadth.		Ratio of Length to Breadth.	
Number of Variates Included in Each Class.	3-4, 5-6, etc. Two in a Class.		.20-39, .40-59, etc. .20 in a Class.		95°-96°, 97°-98°. Two Degrees in a Class.		2-3, 3-4, etc. One Millimeter in a Class.		1-2, 2-3, etc. One Millimeter in a Class.		.30-39, .40-49, etc. .10 in a Class.	
Locality.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.
Harrodsburg. Number of specimens, 276.	3-34	7-8, 37 spec.	.33-2.44	1.00-1.19, 42 spec.	105°-128°	117°-118°, 73 spec.	2-13	5-6, 54 spec.	1½-8½	3-4, 4-5, 71 spec. in each.	1.00-1.71	1.20-1.29, 118 spec.
Pentremite Hollow. Number of specimens, 240.	8-63	35-36, 21 spec.	.80-3.08	2.00-2.19, 71 spec.	96°-125°	107°-108°, 38 spec.	4-22	7-8, 8-9, 10-11, 13-14, in first 3, 17 spec. each; in 4th, 18 spec.	3¼-16	8-9, 32 spec.	.83-1.50	1.20-1.29, 82 spec.
Spergen Hill. Number of specimens, 112.	6-27	23-24, 14 spec.	.64-2.00	1.40-1.59, 31 spec.	102°-127°	107°-108°, 20 spec.	3½-9	7-8, 38 spec.	3-8	6-7, 39 spec.	1.00-1.45	1.00-1.19, 34 spec.
Stinesville. Number of specimens, 48.	5-33	7-8, 9 spec.	.55-2.28	1.00-1.19, 12 spec.	112°-124°	115°-116°, 12 spec.	3-12½	5-6, 12 spec.	2¼-9½	3-4, 16 spec.	1.08-1.46	1.20-1.39, 21 spec.
Hunter Valley. Number of specimens, 38.	6-45	18-19, 4 spec.	.64-2.50	2.00-2.19, 10 spec.	107°-124°	116°-117°, 10 spec.	3-18	5-6, 9 spec.	2¾-17	4-5, 12 spec.	1.00-2.00	1.20-1.29, 16 spec.
Ellettsville. Number of specimens, 21.	13-41	25-26, 4 spec.	1.00-2.23	2.00-2.19, 12 spec.	101°-125°	113°-114°, 4 spec.	5½-15	11-12, 6 spec.	4¼-12½	7-8, 6 spec.	1.13-1.56	1.20-1.29, 10 spec.
All localities. Number of specimens, 735.	3-63	13-14, 63 spec.	.33-3.08	2.00-2.19, 122 spec.	96°-128°	115°-116°, 114 spec.	2-22	5-6, 7-8, 99 and 100 spec.	1½-17	4-5, 118 spec.	.83-2.00	1.20-1.29, 281 spec.

# HARRODSBURG.

	Relative Length of Ambulacral Area.		Angle Between Ambulacral Area and Base.		Length.		Breadth.		Ratio of Length to Breadth.	
Number of Variates in Each Class.	.20-.39, 40-.59, etc. .20 in a Class.		95°-96°, 97°-98°, etc. 2° in a Class.		2-3, 3-4, etc. One Millimeter in a Class.		1-2, 2-3, etc. One Millimeter in a Class.		.30-.39, .40-.49, etc. .10 in a Class.	
Classes Arranged According to Number of Peral Pieces.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.
3-7, 71 spec.	.33-.88	.60-.79, 30 spec.	105°-123°	111°-112°, 115°-116°, 12 spec. each.	2-4	3-4, 38 spec.	1½-3½	2-3, 48 spec.	1.00-1.40	1.10-1.19, 32 spec.
8-12, 77 spec.	.66-1.28	.80-.99, 1.00-1.19, 30 spec. each.	109°-127°	115°-116°, 117°-118°, 21 spec. each.	3¼-6	4-5, 48 spec.	2½-4½	3-4, 53 spec.	1.05-1.50	1.20-1.29, 38 spec.
13-16, 63 spec.	1.00-1.60	1.20-1.39, 27 spec.	112°-128°	115°-116°, 117°-118°, 17 spec. each.	4½-7	5-6, 36 spec.	3½-5½	4-5, 44 spec.	1.09-1.71	1.20-1.29, 36 spec.
17-20, 33 spec.	1.12-1.88	1.40-1.59, 13 spec.	112°-120°	117°-118°, 17 spec.	6-8	7-8, 15 spec.	4½-6	5-6, 24 spec.	1.09-1.45	1.30-1.39, 15 spec.
21-24, 20 spec.	1.44-2.00	1.60-1.79, 11 spec.	112°-122°	117°-118°, 7 spec.	7-9½	8-9, 9 spec.	5½-7	6-7, 11 spec.	1.23-1.50	1.30-1.39, 10 spec.
25-34, 12 spec.	1.63-2.44	2.00-2.19, 7 spec.	108°-120°	117°-118°, 3 spec.	8½-13	9-10, 10-11, 3 spec. each.	6-8½	7-8, 5 spec.	1.33-1.62	1.30-1.39, 5 spec.

## PENTREMITE HOLLOW.

	Relative Length of Ambulacral Area.		Angle Between Ambulacral Area and Base.		Length.		Breadth.		Ratio of Length to Breadth.	
Number of Varieties in Each Class.	.20-.39, .40-.59, etc. .20 in a Class.		93°-96°, 97°-98°, etc. 2° in a Class.		2-3, 3-4, etc. One Millimeter in a Class.		1-2, 2-3, etc. One Millimeter in a Class		.30-.39, .40-.49, etc. .10 in a Class.	
Classes Arranged According to Number of Poral Pieces.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.	Range.	Mode, and Number of Specimens in Mode.
8-12, 8 spec.	.80-1.16	1.00-1.19, 5 spec.	112°-119°	113°-114° 3 spec.	4-5	5-6, 5 spec.	3½-4½	4-5, 7 spec.	1.00-1.25	1.10-1.19, 4 spec.
13-16, 8 spec.	1.00-1.50	1.20-1.39, 4 spec.	98°-119°	111°-112° 3 spec.	5-6½	5-6, 6-7, 4 spec. each.	4½-5	5-6, 5 spec.	.83-1.33	1.10-1.19, 1.20-1.29, 1.30-1.39, 2 spec. each.
17-20, 23 spec.	1.18-1.83	1.40-1.59, 12 spec.	106°-125°	113°-114° 5 spec.	6½-8	7-8, 15 spec.	5-7	6-7, 13 spec.	1.00-1.50	1.00-1.09, 8 spec.
21-24, 31 spec.	1.33-2.00	1.0-1.79, 12 spec.	101°-119°	115°-116° 6 spec.	7-9	8-9, 17 spec.	6-8	7-8, 16 spec.	1.05-1.33	1.20-1.29
25-28, 21 spec.	1.50-2.14	1.80-1.99, 7 spec.	99°-117°	109°-110° 6 spec.	7½-11½	8-9, 8 spec.	6-10½	8-9, 9 spec.	.92-1.41	1.20-1.29, 7 spec.
29-32, 33 spec.	1.20-2.37	2.00-2.19, 15 spec.	97°-114°	103°-104° 8 spec.	8-11½	9-10, 10-11, 13 spec. each.	7-10	8-9, 14 spec.	.88-1.37	1.10-1.19, 18 spec.
33-36, 34 spec.	1.64-3.00	2.00-2.19, 19 spec.	98°-111°	105°-106° 8 spec.	10-14	11-12, 16 spec. each.	8-12½	9-10, 10-11, 11 spec. each.	.84-1.39	1.20-1.29, 14 spec.
37-40, 32 spec.	1.78-2.60	2.00-2.19, 17 spec.	102°-115°	107°-108° 9 spec.	12-15	12-13, 12 spec.	8-13	10-11, 11-12, 11 spec. each.	1.08-1.50	1.20-1.29, 13 spec.
41-44, 20 spec.	1.87-2.66	2.00-2.19, 8 spec.	98°-111°	105°-106° 6 spec.	13-17	14-15, 11 spec.	9½-15	11-12, 7 spec.	1.00-1.37	1.20-1.29, 8 spec.



45-48, 13 spec.	2.12-2.66	2.20-2.39, 5 spec.	99°-112°	99°-100° 101°-102° 103°-104° 105°-106° 109°-110° 2 spec. each.	14-17	14-15, 16-17, 17-18, 4 spec. each.	10-14	11-11½ 5 spec.	1.16-1.47	1.20-1.29, 7 spec. 1.30-1.39, 5 spec.
49-52, 12 spec.	2.23-3.08	2.20-2.39, 5 spec.	96°-109°	105°-106° 4 spec.	15½-18½	18-18½, 6 spec.	11-14½	13 5 spec.	1.25-1.50	
56-63, 5 spec.	2.50-3.00	2.80-2.89, 2 spec.	97°-104°	103°-104° 2 spec.	15-22	15, 19, 20, 21, 22, 1 spec. each.	12-16	14-14½, 2 spec.	1.25-1.42	1.30-1.39, 1.40-1.49, 2 spec. each.

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6-7, 3 spec.	.64-.77	.60-.79, 3 spec.	112°-117°	111°-112°, 2 spec.	3½-3¾	3-4, 3 spec.	3-3¾	3-4, 3 spec.	1.11-1.16	1.10-1.19, 3 spec.
8-12, 8 spec.	.85-1.20	1.00-1.19, 4 spec.	115°-121°	115°-116°, 3 spec.	3½-5½	5-6, 5 spec.	3-4½	3-4, 4 5, each, 1 spec.	1.16-1.42	1.20-1.29, 4 spec.
13-16, 19 spec.	1.00-1.66	1.00-1.19, 8 spec.	104°-124°	111°-112°, 117°-118°, 119°-120°, each, 3 spec.	5-7	5-6, 6-7, each, 9 spec.	3½-6	5-6, 10 spec.	1.05-1.42	1.30-1.39, 6 spec.
17-20, 32 spec.	1.25-1.71	1.40-1.59, 17 spec.	105°-127°	109°-110°, 6 spec.	5¾-8	6-7, 15 spec.	4½-7	5-6, 6-7, each, 14 spec.	1.00-1.45	1.10-1.19, 10 spec.
21-24, 42 spec.	1.37-2.00	1.60-1.79, 14 spec.	102°-121°	107°-108°, 12 spec.	6-9	7-8, 23 spec.	5¼-7¾	6-7, 2 spec.	1.00-1.41	1.20-1.29, 14 spec.
25-27, 8 spec.	1.40-2.00	2.00-2.19, 4 spec.	102°-116°	105°-106°, 107°-108°, each, 2 spec.	7½-9	8-9, 5 spec.	6½-8	7-8, 6 spec.	1.03-1.28	1.10-1.19, 1.20-1.29, each, 3 spec.

Besides the specimens which have been used in obtaining the foregoing data, the writer has examined, as was stated before, almost 5,000 specimens. The smallest specimens which have been obtained were from the Harrodsburg (old Cleveland quarry) material. The distal ends of over a dozen of these small specimens have not been preserved. Five or 6 of the smallest of these (see Fig. 2) are about 0.82 mm. in length and 0.70 mm. in diameter. The bodies of these smallest specimens are conical. The distal

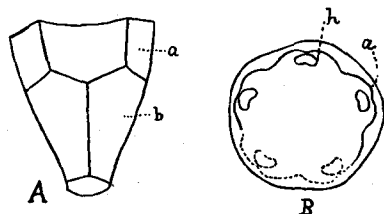


Fig. 2.

Fig. 2. A. Side view of one of the smallest specimens of *Pentremites conoideus*, (a) radials, (b) basals, x 25. B. View of the distal portion of the same specimen, (a) indentation in the rim for the ambulacral area, (h) beginning of the hydrosphere, x 25. Indiana University collection.

ends are circular and the body cavity is either empty or filled with calcareous matter. No structure can be made out with the unaided eye, but a microscopical examination shows that the body is composed of 8 pieces, 5 radials and 3 basals. Prof. G. Hambach\* says that there are 5 basal pieces in the young, but that 2 of the 5 sutures become obliterated in the course of development. In all of the specimens which the writer has examined, she has been unable to find more than 3 basal pieces. In Plate XLVII (Figs. 5 and 6) 3 specimens are given which show the 3 basal pieces with the 3 sutures between. The smallest of the specimens shown in this figure is 1.29 mm. and the 2 larger ones are 1.88 mm. in diameter. The basals form almost two-thirds of the body. As seen from the side there is only a slight downward curve in the upper margins of the radials where the ambulacral areas are to be (see Fig. 2A and Plate XLV, Figs. 3, 4, 5). The same delicate striae which ornament the surface of the adult shell can be seen on the surface of these small specimens. Looking down on the distal

\**Ibid.*, pp. 4-5.

portions of these specimens, the outer rims of the shells appear almost circular with a tendency to be slightly 5 cornered (see Fig. 2B and Plate XLV, Figs. 1 and 2). On the inner side of the rims the 5 ambulacral areas are becoming defined by 5 indentures. In the center of each of these indentations there is a small concave structure which is most probably the beginning of the hydrospire.

In all probability these smallest specimens represent the earliest stage in the development of *Pentremites conoideus*, which can be preserved in the fossil state. They have most likely just emerged from the free-swimming larval stage, grown a shell and assumed the sedentary mode of life. Since the *Pentremites* and the whole group of *Blastoids* are extinct this is as far back as we can go in tracing their development. However, we may speculate to some extent on their earlier development by a study of the embryology of the larger group to which they belong, namely, the *Echinoderms*. Korschelt and Hieder give an excellent presentation of this subject.\* Of the living *Echinoderms* the *crinoids* probably most nearly resemble the *Pentremites*, for many of them were sedentary after the free-swimming stage was passed. In the *crinoids* (*Antedon*) the earliest skeletal pieces begin to form while the larva is still in its free-swimming stage. In the later free-swimming stage the tentacles project into a vestibule. The mouth also opens into this vestibule, "the roof of which is stretched out between the upper margins of the oralia. This roof is at first thick, but gradually becoming thinner finally disappears entirely.

\* \* \* After the disappearance of the roof of the vestibule, the tentacles \* \* \* project free to the exterior. The under-part of the larva has elongated into the stalk, and it now rests with its terminal plate on some support. The fundamentals of the arms bud forth on the upper part of the cup as five projections," etc.

The writer is of the opinion that these smallest *Pentremites* are at about the same stage in their development as has just been described for the *crinoids*. The arms of the *crinoid* are in part homologous to the ambulacral areas of the *Pentremite*. It is very probable that there was some such roof stretched between the upper margins of the radials in the young *Pentremite* as has just been described as being stretched out between the upper margins of the

\*Korschelt and Heider, Textbook of the Embryology of Invertebrates, Part I, pp. 392-461.

oralia in the crinoid. If this is the case it would not be possible to find a Pentremite at this stage of development with the distal portion intact. The roof has probably just disappeared and the ambulacral areas are just beginning to be defined. The next step in the development is the formation of the ambulacral area, with its lancelet piece, poral pieces, hydrospires, etc. As the poral pieces increase in number the ambulacral area grows down. The slight downward curve which is perceptible only with the aid of a microscope in these youngest specimens, gradually increases, until in the adult stage there is an incision or sinus almost the entire length of the radials. The poral pieces always grow at the tip or lower end of the ambulacral area. At the lower or growing end of this area the arrangement of the poral pieces is oblique and rather loose. Toward the top or older end of the ambulacral area the poral pieces are more crowded and have a horizontal arrangement. As the specimen grows the radials elongate, but the basals, which formed the greater part of the body in the youngest specimens, do not grow as rapidly, and in the adult they can not be seen in a side view. When the specimen has about 7 or 8 poral pieces the deltoids begin to show externally. These gradually increase in size as the specimen grows older.

With all these changes in structure, there must necessarily come changes in form. The young have relatively long, tapering bases and short ambulacral areas, while the old have relatively short, flat, or almost concave bases and long ambulacral areas; in other words, the relative length of the ambulacral area increases as the

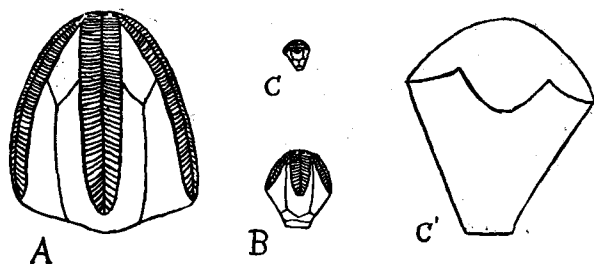


Fig. 3.

Fig. 3. A, B, and C. Large, medium, and small specimens showing the position of the angle between the ambulacral area and the base. x 2. C, enlarged outline of C. Indiana University collection.

specimen grows older. The angle between the ambulacral area and the base is, in general, smaller in the youngest and in the oldest stages and greater in the medium stages of growth. In the young, however, the angle is near the distal end of the body (see Fig. 3), in the old it is at the proximal end, while in the medium specimens it is near the middle. As the specimens grow older they also increase in length and breadth.

In a general survey of a series of specimens which show all these developmental changes (see Plate XLVI), another thing is quite noticeable, namely, the change from the angular to the curved contour of the whole body. As the ambulacral areas grow in length, and the basal pieces do not keep pace with them, there must necessarily be a curving of these areas. In the oldest or most gerontic specimens there is also a tendency for the base to curve downward at the end of each ambulacral area.

Another interesting point has been the comparison of the young of *P. conoideus* with *Codaster* sp. from the Hamilton formation at Thedford, Ontario. The shape of the young Pentromite is almost identical with the shape of the Codaster (see Plate XLVII, Fig. 1.) Each have the long, tapering base and the short ambulacral area. The arrangement of the poral pieces is also quite similar. The young Pentremites have a loose and oblique arrangement of the poral pieces, as have also the Codasters. This similarity between the two would seem to indicate a rather close relationship and gives at least a hint as to the possible ancestry of Pentremites. Codaster may be the ancestor of Pentremites, or Codaster and Pentremites may have descended from a common ancestor.

In examining the 4,400 specimens from Mr. G. K. Greene's collection, the writer has discovered 5 small plates or septa in the oral opening of *Pentremites conoideus*. Three specimens show this structure in an excellent state of preservation; a dozen or more contain all these plates intact, but the preservation is not so good; while a great many others show fragments of them. Altogether there was found about 130 specimens which show all or a part of this structure. The outer end of each plate or septum is attached, in every instance, to the distal end of a lancet piece, that is, to the center of the distal end of an ambulacral area. Each of these 5 plates projects inward toward the center of the mouth opening where they unite. This was the case with the

structure in the 3 best preserved specimens. In some of the others, 2 of the plates seemed to unite before reaching the center of the mouth opening. This, however, may be due to the state of preservation of the structure. The oral opening is thus divided by these plates or septa into 5 small triangular openings. These plates appear to be rather thin and flat, and are arranged so that they stand with the thin edge up. In a great many, perhaps in most cases, this structure is set well down in the oral opening; in other cases it is nearer the top of the opening. The place of attachment of the outer ends of these plates, and their general arrangement, are, however, most constant characters. In every specimen which was found to contain all or a part of these plates intact, the attachment was as described above.

It is difficult to say just what the function of these plates was, but some suggestions might be offered. It is possible that they acted as a sort of strainer which prevented particles of food of too large size from entering through the mouth opening. It is also possible that they served as places of attachment for muscles which controlled the tentacles or perhaps some jaw-like structure. Or, again, it is possible that they had a sort of hinge movement of their own which enabled them to open and close these 5 small openings.

In regard to the genital openings, it is the writer's opinion that there was also some kind of a structure in them, but no specimen has been found in which this structure is well enough preserved to ascertain just what it was.

The regularity of the place of attachment of the plates in the oral opening seems to preclude any doubt of the genuineness of this structure. Prof. G. Hambach\* denies in a very decisive manner the existence of any plates in the mouth or genital openings. One of his arguments against the existence of these plates is the difference in the descriptions and illustrations of the different authors. This difference is probably due, for the most part, to the difference in the preservation of the structures in their respective specimens. This structure, being a very delicate one, is seldom preserved in good condition, and these authors probably based their descriptions upon only 1 or 2 specimens; at least this was

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\**Ibid.*, pp. 15-16.

the case with Shumard. Then, again, some of this difference in descriptions may be due to the individuality of the author. As to Prof. Hambach's idea, that the plates are only little scales or particles of broken pinnulae which have dropped into the summit openings, it is hardly possible that they would always drop into the openings in such a systematic manner as has been described above. And, again, Prof. Hambach says, "It stands to reason, and is only logical to suppose, that if nature provided an opening it should remain open," etc., but he seems to lose sight of this logic, when, in the same paragraph he speaks of "*Olivanites* and others where the center of the summit is closed."

It will be understood, of course, from the description given above, that the present writer does not maintain that the oral opening was entirely closed, as was described and figured by Shumard\*, but it is certainly a fact that there were 5 plates or septa in this opening which divide it into 5 smaller openings.

#### DWARFING OF THE FAUNA OF THE SALEM LIMESTONE.

The studies of the development and variation of *Pentremites conoideus* have led incidentally to a consideration of another point, namely, the dwarfing of the fauna of the Salem Limestone. The fossils from the old Cleveland quarry near Harrodsburg, from which place 276 specimens of my series come, are dwarfed forms quite typical of this formation. The fossils from Pentremite Hollow, near Bloomington (upper part of the Harrodsburg limestone) are normally developed. Two hundred and forty specimens of the above series come from this latter locality. A comparison of the specimens from these 2 localities is interesting.

The data given above in the variation study shows that there are 71 specimens from Harrodsburg which are smaller and which have a smaller number of poral pieces than any specimen from Pentremite Hollow, and that there are 103 specimens from Pentremite Hollow which are larger and which have a greater number of poral pieces than any specimen from Harrodsburg. But there are specimens from both localities having the same number of poral pieces. The number of poral pieces in these specimens ranges from 8 to 34. The measurements of specimens having the

\*Trans. Acad. Sci. of St. Louis, Vol. I, pp. 243-244, Plate ix, Fig. 4.

same number of poral pieces are averaged. This is done for specimens from both localities. The data thus obtained have been tabulated as follows:

HARRODSBURG AND PENTREMITE HOLLOW SPECIMENS COMPARED.

Number of Specimens.	Number of Poral Pieces.	Relative Length of Ambulacral Area.*		Angle Between Ambulacral Area and Base.	Length.	Breadth.	Ratio of Length to Breadth.
P. H. 16	8	2.04 + : 2.43 + mm	.83 +	116°	3.75 mm	3.25 mm	1.15 +
P. H. 1	8	2.00 : 2.50 mm	.80	112°	4.00 mm	3.50 mm	1.14
P. H. 18	10	2.51 + : 2.78 + mm	.90 +	118°	4.46 + mm	3.58 + mm	1.24 +
P. H. 1	10	2.50 : 3.00 mm	.81 +	114°	4.00 mm	4.00 mm	1.00
P. H. 16	11	2.76 + : 2.68 + mm	1.02	117°	4.62 + mm	3.78 + mm	1.22 +
P. H. 2	11	2.75 : 3.00 mm	.91 +	117°	4.75 mm	4.00 mm	1.18 +
P. H. 15	12	3.00 : 2.76 + mm	1.08 +	118°	4.96 + mm	3.95 + mm	1.23 +
P. H. 4	12	3.18 : 3.06 + mm	1.03 +	115°	5.00 mm	4.25 mm	1.17 +
P. H. 13	13	3.38 + : 2.91 + mm	1.16 +	118°	5.32 + mm	4.18 + mm	1.27 +
P. H. 3	13	3.36 + : 3.00 mm	1.12 +	115°	5.44 + mm	4.72 mm	1.15 +
P. H. 15	15	3.81 + : 2.93 + mm	1.30 +	115°	5.71 + mm	4.56 + mm	1.25 +
P. H. 4	15	4.25 : 3.5 mm	1.30 +	113°	6.00 mm	5.00 mm	1.20
P. H. 16	16	4.34 + : 3.32 mm	1.30 +	117°	6.15 + mm	4.84 mm	1.27 +
P. H. 1	16	4.50 : 3.50 mm	1.28	93°	5.00 mm	6.00 mm	.83
P. H. 9	17	4.66 : 3.17 + mm	1.47	116°	6.38 + mm	5.11 mm	1.24 +
P. H. 4	17	5.25 : 3.91 + mm	1.34 +	113°	6.81 + mm	5.79 mm	1.17 +
P. H. 5	18	4.60 : 3.17 mm	1.45 +	119°	6.45 mm	5.05 mm	1.27 +
P. H. 5	18	5.10 : 3.35 mm	1.52 +	115°	6.93 mm	5.80 mm	1.19 +
P. H. 8	19	5.14 : 3.31 + mm	1.55 +	116°	6.87 + mm	5.34 + mm	1.28 +
P. H. 8	19	5.59 + : 3.65 + mm	1.53 +	110°	6.87 + mm	6.03 + mm	1.13 +
P. H. 10	20	5.60 : 3.55 mm	1.57 +	116°	7.37 + mm	5.54 + mm	1.33 +
P. H. 6	20	5.86 : 3.83 + mm	1.53 +	111°	7.30 + mm	6.30 + mm	1.15 +
P. H. 5	21	5.76 + : 3.36 + mm	1.71 +	115°	7.23 + mm	5.55 mm	1.39 +
P. H. 8	21	6.25 : 3.84 + mm	1.63 +	110°	7.58 + mm	5.81 + mm	1.30 +
P. H. 9	22	6.20 + : 3.66 + mm	1.69 +	116°	8.25 + mm	6.11 mm	1.35 +
P. H. 7	22	6.73 + : 4.07 + mm	1.65 +	112°	8.02 + mm	7.04 + mm	1.13 +
P. H. 3	23	6.75 : 3.66 + mm	1.81 +	113°	8.22 mm	6.50 mm	1.26 +
P. H. 10	23	6.92 + : 4.12 + mm	1.67 +	111°	8.01 + mm	6.92 mm	1.30 +
P. H. 3	24	7.11 : 4.16 + mm	1.73 +	119°	9.28 mm	6.83 + mm	1.35 +
P. H. 6	24	7.20 + : 3.91 + mm	1.81 +	108°	8.52 + mm	7.16 + mm	1.18 +
P. H. 4	25	7.25 : 3.81 + mm	1.90 +	115°	8.87 + mm	6.41 + mm	1.38 +
P. H. 4	25	7.12 : 4.00 mm	1.78	109°	8.25 mm	7.00 mm	1.17 +
P. H. 1	26	8.00 : 4.50 mm	1.77 +	120°	10.50 mm	7.50 mm	1.40
P. H. 8	26	8.31 + : 4.56 + mm	1.82 +	109°	9.27 mm	7.93 + mm	1.16 +
P. H. 3	28	8.00 : 4.00 mm	2.00	113°	9.66 + mm	7.00 mm	1.38
P. H. 4	28	8.66 + : 4.75 mm	1.82 +	103°	9.87 + mm	8.50 mm	1.16 +
P. H. 2	29	9.50 : 4.50 mm	2.11 +	113°	12.00 mm	7.50 mm	1.60
P. H. 6	29	8.52 + : 4.75 mm	1.79 +	109°	9.66 + mm	8.00 mm	1.20 +
P. H. 1	31	10.50 : 5.00 mm	2.10 +	110°	12.00 mm	8.00 mm	1.50
P. H. 7	31	9.61 : 5.00 mm	1.92 +	104°	10.25 mm	9.01 + mm	1.13 +
P. H. 1	34	11.00 : 4.50 mm	2.44 +	108°	11.50 mm	8.50 mm	1.35 +
P. H. 5	34	10.60 : 5.50 mm	1.92 +	106°	11.50 mm	9.80 mm	1.17 +

\*The ratio of the numbers in the first two columns is given in the third column.



A study of the data shows that there are 21 sets of comparisons.

In the comparison of the absolute length of the ambulacral area it was found that in 13 out of the 21 comparisons the absolute length of the ambulacral area in the Harrodsburg specimens was less than in the Pentremite Hollow specimens. The average length of the ambulacral area in the Harrodsburg specimens which were compared was 5.80+, and in the Pentremite Hollow specimens it was 5.91+.

The absolute length of the base was found to be less in the Harrodsburg specimens in 19 of these comparisons, and in 1 comparison it was the same in specimens from both localities. The average for all comparisons was, Harrodsburg 3.57+, Pentremite Hollow 3.83+.

The relative length of the ambulacral area was found to be greater in the Harrodsburg specimens than in those from Pentremite Hollow in 17 of these comparisons. In 1 comparison it was the same for specimens from both localities. The average for all comparisons was, Harrodsburg 1.62+, Pentremite Hollow 1.54+.

The angle between the ambulacral area and the radius of the base was greater in Harrodsburg specimens than in specimens from Pentremite Hollow in 20 of these comparisons. In one comparison this angle was the same for specimens from both localities. The average for all comparisons was Harrodsburg 115°, Pentremite Hollow 110°.

The length was greater in the Harrodsburg specimens than in those from Pentremite Hollow in 10 comparisons. In 2 comparisons it was the same for specimens from both localities. The average for all comparisons was Harrodsburg 7.59+, Pentremite Hollow 7.28+.

The breadth was less in the Harrodsburg specimens than in those from Pentremite Hollow in all comparisons. The average for all comparisons was Harrodsburg 5.67+, Pentremite Hollow 6.40+.

The ratio of length to breadth was greater in Harrodsburg specimens than in those from Pentremite Hollow in 20 of these comparisons. In one comparison it was greater in Pentremite Hollow specimens. The average for all comparisons was Harrodsburg 1.33+, Pentremite Hollow 1.15+.

The conclusions which the writer reaches from the data are, first, that the Harrodsburg specimens did not live to be as old as the Pentremite Hollow specimens; second, that there was more of a tendency to crowd the poral pieces into less space in Harrodsburg specimens than in Pentremite Hollow specimens; third, relatively longer ambulacral areas in Harrodsburg specimens means relatively more poral pieces in Harrodsburg than in Pentremite Hollow specimens; fourth, greater angle, greater average length and less breadth in Harrodsburg than in Pentremite Hollow specimens shows that the Harrodsburg specimens were less robust than those from Pentremite Hollow.

In order to learn something as to the possible cause of this dwarfing the writer has reviewed Semper's "Animal Life," Davenport's "Experimental Morphology," and an article "On the Correlation Between Growth and Food Supply in Starfish," by A. D. Mead [Amer. Nat. 1900, pp. 17-23]. Below is given a brief resumé of the conclusions of these authors.

Mead considered only the food supply as a cause of dwarfing. He concluded that insufficient food alone would cause dwarfing in the starfish.

Semper also mentions insufficient food as a cause of dwarfing. Quality of food is also considered, but he concluded that the organs of digestion were affected more by this than the whole size of the animal. Too low or too variable temperature is also a cause of dwarfing, but the variable temperature is more detrimental to growth than a constant low temperature. Variation in the amount of salt in the water will sometimes hinder the growth of animals.

Davenport agrees with Semper that animals in a small body of water are smaller than animals in a large body of water. Davenport also concluded that increasing the number of individuals in a vessel has the same effect as diminishing the volume of water. In considering the effect of the density of a solution, Davenport concluded that to increase this density beyond the normal would cause the rate of growth of animals living in it to be diminished. He also concluded that diminished oxygen retards growth.

Another point which was discussed by Semper is an explanation regarding the rich variety of the fauna in the Mediterranean and

the Red Seas. His explanation for this richness of forms is not the greater saltness, as is claimed by some, but that the superficial currents carry swimming creatures and the larvæ of non-migratory animals into these seas through the narrow straits and that many more creatures are brought in than are carried out.

Let us now consider the possible cause of the dwarfing of the fauna of the Salem Limestone. We know from the foregoing study that the conditions in the sea in which the Harrodsburg specimens lived must not have been favorable to longevity or to robust growth. It is difficult to say just what these unfavorable conditions were, but, in the light of the foregoing statements let us see what conclusions we can draw in regard to them. We know that the sea must have been teeming with life, for the Salem limestone is very rich in fossils. We might explain this richness of the fauna in the same way as Semper explains the rich variety of forms in the Mediterranean and Red Seas, namely, because the currents carried more creatures in than were carried out. There may have been coral-reefs not very far out from the shore-line which partially enclosed that portion of the sea in which the Salem limestone was laid down. Judging from the cross-bedding which quite frequently occurs in this limestone it is very probable that there were currents and that the sea was shallow. It is also probable that the shore was low and perhaps almost swampy, because the limestone is free from sediment which would have been carried into the sea had the adjacent land been high. The conditions along this ancient shore-line must have been similar to those which now exist along the southern Florida coast, and as far as the clearness and depth of the water was concerned it must have been favorable to the growth of coral reefs. If there were currents, there must also have been a sufficient food supply. It is quite probable, therefore, that the coral reefs existed. The Salem limestone was probably laid down in a lagoon or partially enclosed sea, and the dwarfing of the fauna was perhaps due, in part, to the smallness of the body of water and to an overcrowding. According to Semper and Davenport this in itself would cause dwarfing. There is another point, however, which has been brought out by the above comparison of the dwarfed and normal forms, which

might give us a hint as to another cause, namely, the slight tendency for the Harrodsburg specimens to have relatively longer ambulacral areas and hence relatively more poral pieces than the Pentremite Hollow specimens. Since the poral pieces are connected with the hydrospires, which are regarded as the respiratory organs of Pentremites, their increased number would indicate an effort of the animal to adapt itself to a depletion of oxygen in this ancient sea.

## ECHINODERMA.

BY J. W. BEEDE.

### BATOCRINUS ICOSIDACTYLUS Casseday.

Plate XII, figs. 6-6b.

*Batocrinus icosidactylus* Casseday, Zeitschrift d. Deutsch. Geol. Gesellsch., VI, p. 238, pl. II, ff. 1, 1a-c, 1854.

Wachsmuth and Springer's description: "Calyx nearly as wide as high. Dorsal cup rarely more than half the height of the ventral disk, low saucer-shaped, with a protuberant base; plates heavy, slightly convex, their surface smooth or obscurely granular.

"Basal cup projecting conspicuously beyond the level of surrounding plates, almost circular in outline; the median part deeply depressed for the reception of the column; central perforation sub-pentangular. Radials short, partly hidden from view by the overhanging rim of the basals. First costals quadrangular, three times as wide as long, narrower than the second. Distichals two, a little larger than the costals. Palmers three, increasing in width upward and placed in longitudinal series, which are separated by well defined grooves. Arm openings facing laterally, forming a continuous row around the calyx. Arms four to each ray; their structure not known. Interbrachials three (rarely four) to the inter-radius; the first much larger than the other two. The anal plate, which resembles the radials, is followed by three plates, and these by one or two. Interbrachials not connected with the plates of the tegmen, the higher brachials being in lateral contact. Ventral disk conical, passing gradually into a strong, almost central tube. The larger plates, as a rule, are extended into thorn-like projections, and are surrounded by smaller, slightly convex pieces. Orals quite excentric, four of them spinous, the posterior one merely convex. The radial dome plates, which are represented by plates of a first, second and third order, are also spiniferous. Anal tube long, heavy, and composed of convex pieces, among which larger thorn-like plates are scattered at intervals. Column round."

Localities: Lanesville, Paynters Hill, Spergen Hill.

## BATOCRINUS IRREGULARIS Casseday.

Plate XII, figs. 1-1a.

*Batocrinus irregularis* Casseday, Zeitschr. d. Deutsch. Geol. Gesellsch., Vi, p. 240, pl. II, ff. 2a-c, 1854.

"Resembling the preceding species, but readily distinguished by its smaller size, more elongate form, much greater depth of the dorsal cup, by having a less number of arms, and the absence of spiniferous plates in the tegmen. Surface of plates smooth or slightly wrinkled, the radial ones transversely ridged; suture lines distinct.

"Basal cup projecting, circular in outline, deeply excavated for the attachment of the column. Radials short, considerably wider than the costals. Costals small, quadrangular, twice as wide as long; succeeded in four of the rays by 2x2 distichals, which resemble the costals in form and size, and support 2x2x2 fixed palmers. In the anterior ray there are two rows of three successive distichals followed by the free arms. Arms eighteen, the ambulachral openings directed horizontally. Interambulachral plates three; the first larger, supporting two plates in the second range. The anal piece is succeeded by three plates, and one above. Tegmen high-conical, higher than the dorsal cup; composed of comparatively few, large, tumid plates. Anal tube stout, almost central; constructed of strongly nodose pieces. Arms and column unknown."

Localities.—Lanesville, Paynters Hill, Spergen Hill.

## BATOCRINUS MAGNIROSTRIS Rowley.

Plate XV, figs. 1-3.

*Batocrinus magnirostris* Rowley, Cont. Ind. Pal., I, pt. XVII, p. 170, pl. LI, ff. 1-3, 1904.

"In this species the ventral disk is deeper than the dorsal cup and the base of the ventral tube is very strong. The calyx rapidly expands from the basal plates and forms a low cone. The three basal plates form a distinct rim. The columnar canal is round. The ornamentation of the plates of the dorsal cup consists of fine, radial lines and low radiating ridges. The final radial is broader than long and has a slight cross ridge. The second radial is quad-

angular, broader than long, and has a low cross ridge. The third radial is pentagonal, broader than long, and has a cross ridge as in the first and second plates. There is another bifurcation above the third primary radial. A slender thread-like line traverses the radial series from the base to the arms. The first interrarial plate sends off indistinct radiating ridges from the center. Above this latter plate are one or two smaller plates. There are eighteen arm bases, four to the ray, except the one opposite to the anal area, which has but two. To each group there are always two large respiratory pores, or ten in all. The plates of the ventral disk are strongly nodose and the nodes are sharp. The ornamentation of the dorsal cup reminds one of delicate ripples. The proboscis (ventral tube) is stout, long and nodose. The plates are rather thick." (Rowley.)

Locality: Lanesville.

I have seen no authentic examples of this species.

**BATOCRINUS SALEMENSIS** Miller and Gurley.

Plate XII, figs. 2-2b.

*Batocrinus salemensis* Miller and Gurley, Bull. No. 9, Ill. State Mus. Nat. Hist., p. 8, pl. I, ff. 10-12, 1896.

"Species small, vault and calyx subequal, depressed, biturbinate. Calyx saucer-shaped, between one and three times as wide as high. Plates convex, radial series somewhat angular. Ambulachral openings directed horizontally.

"Basal plates form an hexagonal disc one-half wider than the diameter of the column and having a height equal to about one-fourth the diameter of the column. The depression for the attachment of the column is hemispherical. The first primary radials are between two and three times as wide as long, three hexagonal, two heptagonal. Second primary radials quadrangular, short, from three to five times as wide as long. Third primary radials only a little larger than the second, from three to four times as wide as long, pentagonal, axillary, and, in four of the rays, bear upon each upper sloping side two secondary radials, the last ones of which are axillary, and bear upon the upper sloping side two tertiary, which gives to each of these rays four arms. In the ray opposite the azygous area, the third pri-

mary radial bears upon each upper sloping side three secondary radials, which gives to it two arms. There are, therefore, eighteen arms in this species, and eighteen ambulacral openings to the vault.

"In each of two of the interradial areas there are three plates, one large followed by two small plates. In each of the other two areas there are only two plates, one large plate followed by one plate in the second range. In the azygous area there are six plates. The first one is in line with the first primary radials and nearly as large, it is followed in the second range by three plates, above which there are two plates. One is above the middle plate and one is to the right of it.

"The vault is moderately convex, covered with polygonal spinous plates, and bears a subcentral proboscis. No ovarian pores have been discovered.

"This species is distinguished among the eighteen armed species, by its general form, surface ornamentation, two secondary radials, and by the interradial azygous areas.

"It was found in the Warsaw group, at Salem, Indiana, and is now in the collection of Charles L. Faber."

#### BATOCRINUS SACCULUS Miller and Gurley.

Plate XII, figs. 7-7b.

*Batocrinus sacculus* Miller and Gurley, Bull. 5, Ill. State Mus. Nat. Hist., p. 52, pl. V, ff. 7-9, 1894.

"Body of medium size. Calyx somewhat saucer-shaped, three times as wide as high; arms directed horizontally; plates convex, sutures distinct; surface granular. Our specimen is a little depressed below, so as to produce an unnatural concavity around the column, and, therefore, does not show the full height of the calyx; it appears to be four times as wide as high, but remove the depression and it will not be more than three times as wide as high. The column is round, and plates rather thick and beveled toward the sutures so as to make them sharply angular in the middle.

"Basals small, low, and extending only a little beyond the column. The first radials small, one-half wider than high. Second radials two-thirds as large as the first, quadrangular and only a little wider than long. Third radials very little larger than the



second, four pentagonal, the one opposite the azygous area heptagonal, axillary and bear upon each upper sloping side a tertiary radial. In the ray opposite the azygous area the second secondary radials are rather large and bear the free arms. This gives to the species eighteen arms. The arms are small and directed horizontally.

"There are three plates in each regular interrarial area, the first are the larger plates of the calyx, and each is followed by two rather long plates. In one or two of the areas there is a small plate above these. The first azygous plate is a little larger than the first radials and it is followed by four plates in the second series; above these the sutures are obscure in our specimens, but apparently there are three in the third series and above these there is one or two plates that connect with the plates of the vault.

"The vault is convex, most ventricose on the side opposite the azygous area. It is fully as large as the calyx and bears a very small subcentral proboscis. It is covered with rather large, polygonal, convex plates, and is slightly depressed in the interrarial areas.

"This species somewhat resembles in form *B. spergenensis*, but differs in the interrarial and azygous areas, beside that is a twenty-armed species while this has only eighteen. It will not be mistaken for any hitherto described.

"Found in the Warsaw group, in Washington County, Indiana, and now in the collection of Wm. F. E. Gurley."

#### BATOCRINUS CALYCVLUS Hall.

Plate XIV, figs. 3-3b.

*Actinocrinus calyculus* Hall, Supp. vol. I, pt. II, Geol. Rep. Ia., p. 55, pl. I, ff. 12a-c, 1860.

"Body depressed turbinate below the arms and abruptly conical above, probosics a little excentric on the anal side; base rounded, plates short, with the lower margins forming a projecting rim, within which is a shallow symmetrical depression for the reception of the column; the edges of the plates a little elevated on each side of the suture line. Radial plates short, the second often not fully developed; the third radial supporting two series of secondaries or supraradials, of which the lower ones are quadrangular and the

upper ones larger and pentagonal, each one of the latter supporting two brachial plates, and these each an arm plate in direct succession, giving origin to four arms to each ray except the anterior ray, where there are but two arms, the secondaries in direct line to the arm plates. First interrarial plate 10 or 11 sided; second interrarial small or often not developed. First anal plate large, wider than long; second anal plates, three, of which the central one is larger than the first radial, and supports in part the brachial plates of the adjacent rays. Dome abruptly conical, composed of small acutely spiniferous plates. Proboscis undetermined. Surface of plates marked by short undulating or subgranulose ridges, which have the general character of radiating from the center of the plates. This small species differs from any other in this rock, and, though approaching some of the forms in the Burlington limestone, is nevertheless quite distinct."

Locality: Spergen Hill.

BATOCRINUS DAVISI Rowley.

Plate XV, figs. 7, 8, 9.

*Batocrinus davis* Rowley, Cont. Ind. Pal., I, p. 171, pl. 51, ff. 7-9, 1904.

"This is another 18-armed form, with convex calix plates, the latter ornamented by short, irregular raised lines and pits of a most delicate character. A slight raised line connects the radial plates.

"The radials are wider than long, and there are two bifurcations to the ray in four radial rays.

"The first interrarial is larger and supports two smaller plates above.

"The basal plates form a rim. The column is rather large and the perforation round.

"The ventral disk is as deep as the dorsal cup, and the plates are nodose-spinose.

"The anal tube is central and strong and probably nodose.

"The first plate of the anal interradius supports three plates above, and above them are three others.

"Horizon, locality and collection same as last (Lanesville).

"This specimen was originally described from the Kaskaskian limestone."

## BATOCRINUS CRASSITESTUS Rowley.

Plate XV, figs. 10, 11, 12.

*Batocrinus crassitestus* Rowley, Cont. Ind. Pal., I, p. 172, pl. 51, ff. 10-12, 1904.

"This crinoid is subglobose, with a deeper ventral disk than dorsal cup.

"The broad plates form a distinct rim and, as in the preceding forms, the radial plates are convex and wider than long and slightly connected by a low line. There are two bifurcations to the ray except in the anterior ray.

"The large first interrarial plate is 9 or 10 sided, convex, with indistinct lines radiating from its center. Above it are one or two smaller convex plates.

"The first anal interrarial is twice as wide as long, and supports three larger convex plates above. Upon these three plates rest two other plates of nearly equal size. A small plate lies above these two.

"There are eighteen arm bases in five groups, with two respiratory pores to the group, or ten in all.

"The plates of the ventral disk are strongly nodose, almost spinose, but with no definite arrangement to the nodes.

"The proboscis or ventral tube is subcentral and very strong, also nodose. The body plates are all thick." (Rowley.)

Locality: Lanesville.

## BATOCRINUS DAVISI LANESVILLENSIS (Rowley).

Plate XV, figs. 13, 14, 15.

*Batocrinus davisii* var. *lanesvillensis* Rowley, Cont. Ind. Pal., I, p. 172, pl. 51, ff. 13-15, 1904.

"In this crinoid the depth of the dorsal cup and the ventral disk are about the same.

"The basal plates form a slight rim. The stem is rather large and the perforation large.

"All of the radial plates are somewhat wider than long, a very little convex and all connecting by a single line.

"The first interrarial plate is the largest plate on the dorsal cup and about as long as wide, a little convex, with the slightest ap-

pearance of radiating ridges. Above this plate are two smaller ones, and two yet smaller above the latter two.

"There are nineteen arm bases with 2 pairs of respiratory pores for each group, or twenty in all.

"The arm groups are somewhat grouped in this form, unlike the previously described forms.

"The plates of the ventral disk are convex and each with a small nipple-like spine.

"The anal tube is only moderately strong, and with convex plates bearing central nodes.

"The first plate of the anal area is a little longer than the first radial plate, and supports above three rather large plates. Above these latter appear to be two smaller plates." (Rowley.)

Locality: Lanesville.

#### BATOCRINUS DAVISI, SCULPTUS (Rowley).

Plate XV, figs. 22, 23.

*Batocrinus davisi* var. *Sculptus* Rowley, Cont. Ind. Pal., I, p. 174, pl. 51, ff. 22, 23, 1904.

"The dorsal and ventral cups are of equal depth.

"The column rather large and the basal plates forming a low rim.

"All of the calyx plates are a little convex with fine radiate-line sculpture, a delicate ridge traversing the radial plates. The fine radiating ridges are often broken up and on some plates display no definite arrangement, crossing some of the radial plates entirely.

"The radial plates are wider than long and the radial series embraces three orders of plates.

"The interradial series contains four plates, 1, 2, 1, the lower one being the largest plate in the dorsal cup.

"The anal area has eight plates, 1, 3, 3, 1.

"The plates of the ventral disk are smooth and convex, some of them having a low, nipple-like central node.

"The anal tube is not very strong and located near the center.

"There are eighteen arm bases, the anterior ray having but two.

"The ornamentation of the dorsal cup of this form will readily distinguish it." (Rowley.)

Locality: Lanesville.

## DIZYGOCRINUS WHITEI Wachsmuth and Springer.

Plate XII, figs. 4-4a.

*Batocrinus whitei* Wachsmuth and Springer, Proc. Acad. Nat. Sci. Phil., p. 343 (Rev. Palaeogr.), 1881.

"Calyx small, depressed globose; dorsal cup equal to, or but little higher than, the ventral disk; the arm regions slightly projecting. Surface of plates ornamented. The radials and brachials have along their medial lines a well defined ridge, and at each side of this ridge, toward the sides of the plates, an annular node, which appears in the specimens as forming an independent plate. Ridges or rows of small tubercles occur also on the interbrachials, some of them proceeding from the center of the first plate to the radials, others to the higher interbrachials.

"Basals short, forming a projecting circular rim, with a shallow striated depression for the reception of the column. Radials twice as wide as long; the sloping upper sides shorter than the corresponding lower ones. Costals considerably shorter and narrower than the radials; the first quadrangular, and the second pentangular. Distichals 2x2, of similar form, but smaller than the costals; in the anterior ray supporting the arms; in the other rays followed by 2 rows of palmers. The upper faces of all arm-bearing plates are directed outward and formed into circular, rather large facets with a notch at the upper end. The surface of these facets is slightly concave and grooved at the inner margin. Arms 18, single, infolding, gradually tapering, and constructed from the second free plate of 2 series of moderately long pieces. Pinnules very long, composed of joints 3 times longer than wide. Interbrachials: 1, 2, 1, sometimes with an additional narrow piece between the arms. Anal plate somewhat higher than the radials, and followed variously by 3, 3 and 2 plates or by 3, 2, 1 and 1; the latter being generally the case in specimens from the Keokuk group, the former in those from the Warsaw limestone. Plates of the ventral disk of nearly equal size, all covered with a sharp central tubercle. Anal tube long, extending beyond the tips of the arms, constructed of convex plates interspersed with slightly nodose or spinous pieces. Column slender; composed of large and smaller joints, the larger ones with convex edges."

Localities: Lanesville?, Paynters Hill? and Spergen Hill.

"Miller's *Batocrinus spergenensis* was described from a specimen of *Dizygocrinus whitei* from which the surface markings were eliminated by weathering." (W. & S.)

There are young crinoids occurring at Paynters Hill and Spergen Hill which in all probability belong to this species, *D. euconus* and others but which can not be referred to any species with certainty. Some of these are figured, others are omitted, though they are good specimens. Wachsmuth and Springer remark some of these crinoids occurring in the Warsaw have more plates than those of the Keokuk and Burlington. As would be expected, the young specimens of the Salem limestone have fewer anal and interradial plates than the adults. Not infrequently these tiny plates may be discovered with the lens just making their appearance.

DIZYGOCRINUS EUCONUS Meek and Worthen.

Plate XII, fig. 3; Plate XVI, figs. 2-2a.

*Actinocrinus (Alloprosallocrinus) euconus* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 164, 1865.

Wachsmuth and Springer's description: "In general form resembling *Alloprosallocrinus*. Dorsal cup very slightly convex, the sides spreading abruptly from the top of the basals to the arms. Base small, projecting, circular in outline, with shallow depression for the reception of the column. Surface of plates smooth, without ridges or other elevations. Suture lines indistinct. Radials hexagonal, about twice as wide as high. First costals quadrangular, smaller than the second. Distichals 2, followed in the antero-lateral rays by 2 rows of palmers, and 4 single arms; while the anterior ray, which has an additional distichal at each side, and no palmers, has 2 arms. The posterior rays have palmers in the division next to the anal side and 3 arms, there being 16 arms in the species. Structure of the arms unknown. Interradials 3 at the regular sides and 6 above the anal plate, the upper row at all sides arched by the armbearing brachials. Ventral disk regularly conical, twice as high as the dorsal cup, composed of rather large, convex pieces; the posterior oral erect and forming the base of the anal tube. The tube is stout at the base and nearly central."

Locality: Spergen Hill.

## DIZYGOCRINUS UNIONENSIS Worthen.

Plate XVI, figs. 1-1d.

*Batocrinus unionensis* Worthen, Geol. Surv. Ill., VII, p. 84, pl. XII, ff. 5-5a; pl. 13, f. 3, 1890.

"Body depressed globose, width at the base of the arms a little greater than the height to the base of the ventral tube. Plates of the calyx strongly beveled on the corners, leaving a deep suture between them on all sides. Dome elevated, composed of plates that are elevated in the center, forming short and rather stout nodes. Basal plates very small and concealed in the basal cup. First radials one and a half as wide as the second, and projecting so as to form a rim around the basal cavity. Second radials quadrangular and nearly twice as wide as long. Third radials pentagonal, axillary, and supporting on their upper sloping sides the secondary series. The secondary and tertiary radial series consist of three plates each, the last one of the third series giving support to the first arm plates. First anal plate hexagonal, and succeeded by two smaller ones in a double series. Arms composed of a double series of interlocking plates. Ventral tube slender, column unknown." (Rowley.)

Locality.—Lanesville.

## DIZYGOCRINUS DECORIS Miller.

Plate XII, figs. 5-5a; Plate XVI, fig. 4.

*Batocrinus decoris* Miller, 17th Ann. Ind. Dept. Geol. Nat. Res., p. 671, pl. X, ff. 7, 8, 1892.

"Species above medium size; calyx depressed, nearly flat; radials form angular ridges from basals to free arms; interrarial areas flattened, though the plates are somewhat convex and bear small tubercles or small coarse granules; arm openings horizontal.

"Basals three, forming a rather large disc, which bears a round or obscurely hexagonal rim extending below the radial ridges, and within which there is a deep concavity for the columnar attachment. First primary radials about four times as wide as long. Second radials quadrangular, about three and a half times as wide as long. Third radials pentagonal, nearly three times as wide as long and support the secondary radials. There are two second-

ary radials in each series; the first usually abuts two interradians and therefore becomes pentagonal, it is about twice as wide as long, the second is more than twice as wide as long, axillary, and supports upon each upper sloping side three tertiary radials. The tertiary radials are short and wide; each of the first ones abut an interradian; the second unite around the calyx, cutting off connection between the azygous area and the vault; they are axillary and bear either a double series of arm plates or bifurcating arms. The arms are not preserved in our specimen. There are twenty arm openings, four for each radial series.

"Regular interradians four; the first one is large, bears a central tubercle, and is followed by two of unequal size and length, and beyond the longer of these there is a narrow elongated plate that separates the tertiary radials and inserts an angle between the under sloping sides of the second tertiary radials. Azygous interradians eight and possibly nine; the illustration shows only five, but the lower central ones consist of two anchylosed plates and each of the upper ones should be divided. Vault high, conoidal, covered with unequal, more or less convex polygonal plates, three of which, above each of the five radial series, is produced into an obtuse spine. The proboscis is subcentral, and where broken off, in our specimen, rather large; length unknown.

"Found in the Warsaw group, at Spergen Hill, Indiana, and now in the collection of Wm. F. E. Gurley." (Miller.)

#### DIZYGOCRINUS? SP.

Plate XVII, fig. 7.

Specimen of rather small size, depressed subglobose, truncated below. Dorsal cup nearly flat to the upper costals, where it rounds slowly upward to the top of the distichals, which face outward. Vault somewhat flattened on the posterior side, quite full in the anterior region; tube small, subcentral, height unknown. Arms eighteen. Basals three, forming a shallow cup for the reception of the column, which covers about three-fourths their area. They are produced into a small ring below the radials. Radials rather large, hexagonal, slightly concave above. Brachials two, the first nearly as large as the radials, quadrangular; the second larger than the plates below, hexagonal, axillary, supporting two series of cos-



tals of two plates each, except in the anterior, in which there are three in the series, the last of which supports an arm. Distichals two in each series, supported by the axillary upper costals. Facets somewhat semicircular, or U-shaped. Arm openings large. The plates of the vault are convex and some are pointed. They are smaller and flatter on the posterior side. Interradials 1, 2, 1, the last supporting a narrow interambulacral connecting with the vault. Anal plate heptagonal, smaller than the radials, supporting 3, 3, 3, 2 plates, the last two supporting plates which connect with the vault. All plates of the calyx are somewhat convex. Each ray is marked with a bifurcating keel, reaching to the arms. The smaller surface markings are unknown.

Locality.—Lanesville.

Without the arms and complete tube it is impossible to refer this species to the proper genus. Until these are known it is of little use to apply a specific term to it.

The specimen belongs to Mr. G. K. Greene.

#### PLATYCRINUS BONOENSIS White.

Plate XIII, fig. 2.

*Platycrinus bonoensis* White, Proc. Acad. Nat. Sci. Phil., p. 30, 1878.

Wachsmuth and Springer's Description.—“Closely allied to the preceding species [*P. niotensis*], but having five to six arms to the ray instead of four, and these are proportionately shorter, more closely packed, and heavier. Dorsal cup wider than high, bowl-shaped, a little spreading, the margins of the plates slightly beveled, giving to the central portions a slight convexity. Surface without ornamentation.

“Basals proportionately small, forming a shallow basin, broadly truncated below and excavated at the bottom, the sides somewhat constricted so as to form a rounded projecting edge around the lower margins; the interbasal suture lines slightly elevated. Radials wider than long, gradually expanding upwards, the upper angles truncated, deeper at the anal side. Facets from one-half to two-thirds the width of the radials; semicircular. Costals small, trigonal, rarely covering the full width of the facets, and the distichals abut against the radials. First distichals once and a half

as wide as long, the axillary one a little wider and somewhat higher. The latter gives off an arm to the outer side of the ray and supports at the inner two palmers with two arms, making three arms to each subdivision, or six to the ray, exceptionally five. The arms are stout, especially in the middle, and quite short; they are uniserial to the fourth plate, beyond this biserial. Column slightly elliptic and twisted."

Locality.—Bono, Lawrence County.

PLATYCRINUS BOONVILLENSIS Miller.

Plate XIV, figs. 5-5b.

*Platycrinus boonvillensis* Miller, Bull. Geol. Surv. Mo., No. IV, p. 8, pl. I, ff. 1, 2, 1891.

Wachsmuth and Springer's Description.—"A rather large species of the type *P. burlingtonensis*. Calyx to the top of the radials bowl-shaped, wider than high, slightly pentagonal as seen from above. Plates moderately heavy, the surface smooth or nearly so; the basi-radial and interrarial sutures grooved. Basals closely anchylosed, the lines of union elevated into ridges; they form a low, rapidly spreading basin, distinctly pentangular at the upper end, broadly truncated at the lower, the bottom deeply excavated so as to form a rounded, rugose rim around the column. Column facet circular, occupying one-half the concavity, its face covered with radiating striae. Radials a little wider than long, gradually expanding upwards, slightly more elevated along the median line, and somewhat beveled toward the sutures. The facets occupy less than half the width of the plates; they are shallow, directed upwards and surrounded by a projecting rim."

Locality.—Spergen Hill.

POTERIOCRINUS CORYPHEUS Miller.

Plate XIII, figs. 1-1a.

*Poteriocrinus coryphaeus* Miller, 17th Ann. Rep. Ind. Geol. Surv., p. 654, pl. IX, f. 1, 1892. Avd. Sheets do, 1891.

"Species robust, arms large and long in comparison with the size of the calyx, and fit closely together. Calyx subturbinate, height a little more than the diameter; sutures distinct, surface granular.

Basals gradually expanding and forming a pentagonal cup. Subradials larger than the basals and longer than wide. The first radials about the same size as the subradials, wider than long, and truncated the entire width above and separated from the single brachials by a gaping suture. Brachials pentagonal, wider than long, rounded and constricted in the middle, and support free arms upon their sloping sides. In the ray on each side of the azygous area and in the one opposite the area, the brachials are followed, on each upper side, by a long, round, axillary plate, giving to each of these rays four arms. The two lateral brachials bear only two arms each. There are no other divisions of the rays. This gives to the species sixteen arms. The first plates are long, but they gradually shorten and become more and more cuneiform. The arms are flattened on the sides and fit closely together. Pinules long and coarse. The azygous area exposes five plates arranged as in other species in this genus. The first azygous plate is smaller than the second and rests between the upper sloping sides of the two subradials and the upper sloping side of the first radial on the right, and supports the third azygous plate. The second azygous plate broadly truncates a subradial. Column round, moderately large.

"Distinguished from other species by the number and character of the arms."

Locality.—Paynters Hill. The type was found in the Keokuk beds of Indian Creek, Crawford County, Indiana. The specimen figured is from the Paynters Hill, and belongs to the American Museum.

The specimen has the basal part of the calyx broken away, only the radials showing. The brachials in our specimen are about as wide as long, instead of wider than long, in this respect it approaches *P. amoena*.

ICTHYOCRINUS CLARKENSIS Miller and Gurley.

Plate XIV, fig. 4.

*Ichthyocrinus clarkensis* Miller and Gurley, Bull. V, Ill. St. Mus. Nat. Hist., p. 43, pl. IV, f. 5, 1894.

"Species small. Our specimen is compressed, but the general form with the arms folded is subovate. The plates are free from spines and nodes; the sutures are very distinct and slightly ar-

cuate, the superior plates generally overlap the inferior ones in the middle part. The column is very large and entirely covers the basals and subradials, so they have not been observed. There are no interradials.

"There are three primary radials in each series. They widen rapidly and are subequal in length. The different series interlock instead of having a straight separating suture. There are four secondary radials in each series of about the same length, and each plate has about the same length as a primary radial, they expand very little, so that the fourth axillary plate is not much wider than the first plate. The different series interlock in the same manner that the primary series do. The fourth plate supports upon each upper sloping side a single non-bifurcating arm, which gives the species twenty arms. The arms are composed of short quadrangular plates, with arcuate sutures. There are twelve plates in some of the arms on our specimen, and if complete there would probably be as many more."

Locality.—"Found in the Keokuk or Warsaw Group, in Clark County, Indiana, and now in the collection of Wm. F. E. Gurley."

#### DICHOCRINUS STRIATUS Owen and Shumard?

Plate XIII, figs. 5-5b.

*Dichocrinus striatus* Owen and Shumard, Jour. Acad. Nat. Sci. Phil. (2), II, p. 62, pl. VII, f. 10, 1850.

Calyx small, basal portion enlarging rapidly, sides convex, or approaching cup-shape, ornamented by about thirty lines radiating from the base in six rhombs. About eighteen of these lines reach the base. The sutures between the two basal plates lie in a narrow space which separates these markings into two distinct sets. The base is truncated below. The calyx is widest at the union of the basal and radial plates and somewhat constricted above. The sutures of the upper part of the calyx can not be made out in the specimen at hand. The top of the calyx is roughly pentangular, probably sometimes hexangular. There is a tendency of some of the lines of ornamentation to converge at the arm facets. The arm facets are roughly semicircular and small. The height is almost equal to the width. The columnar facet is round, small and

truncating the base of the calyx, bordered by the ends of the ornamental ridges.

Localities.—Paynters Hill, Harrodsburg.

The only complete calyx we have of this species is from Harrodsburg, and is quite small. It is to be remembered that these fossils become relatively much more robust with age, and the surface marks become, perhaps, better defined. While our specimen, and the basals from Paynter's Hill (agreeing better in some respects with the types), differ somewhat in form and markings from this species, it is referred here provisionally, as adult specimens might prove to be identical with *D. striatus*, notwithstanding the fact that, as yet, that species is not known to occur in rocks younger than the Keokuk.

#### DICHOCRINUS BLATCHLEYI N. SP.

Plate XVII, figs. 2-2f.

Dorsal cup deeply basin-shaped, truncated below for the attachment of the column, the facet surrounded by a small ring and bordered by the lower ends of the radiating ridges which form the surface marks of the lower part of the basal plates. These ridges are undulating and somewhat nodose, and end in the middle of the plate in a series of large pustules, above which are undulating transverse ridges, four or more, which may be either distinct, united with each other or broken. The plates are very thin. The radials, judging from loose plates, have about three horizontal ridges below, like the top of the basals, followed by six vertical ones on the upper part. The radials are wider below than above, higher than wide, with half or more of the top faceted for the reception of the superjacent structure. Facets semicircular with crenulated outer margins.

Locality.—Paynters Hill.

It is a dangerous thing to erect a species of crinoid upon surface marks, but in this limited genus of thin-plated crinoids there is no known species approaching this in its striking surface characteristics. They are much more like the surface features of some species of *Platycrinus*.

## DICHOCRINUS OBLONGUS Wachsmuth and Springer.

Plate XIII, fig. 9.

*Dichocrinus oblongus* Wachsmuth and Springer, N. Amer. Crin. Cam., p. 759, pl. LXXVII, f. 9, 1897.

"In style of ornamentation resembling *D. striatus*, from which it differs essentially in its very elongate calyx and in the proportion of the plates. Calyx almost twice as high as wide, obconical, not contracted at the upper end; the sides convex. Surface covered by six sets of from five to six rather prominent, longitudinal ridges, which in gentle curves pass from the facets of the radials and top of the anal plate to the foot of the basals. These ridges do not cover the entire surface of the calyx, but leave upon the lateral margins of adjoining radials a trigonal space, divided by the interrarial suture, and covered by obscure, longitudinal ridges, which rest obliquely against the other ridges.

"Basal cup conical, almost as high as the radials, and nearly as high as wide; slightly truncated at the bottom; the upper face but little excavated. Radials once and a half as long as the width at the lower end, a little wider above than below, the lower face almost straight; facets narrow, a little concave and slightly protruding outward. Structure of arms and ventral disk not known."

Locality.—"Near Bloomington."

## TALAROCRINUS SP. CF. TRIJUGUS Miller and Gurley.

Plate XIII, fig. 8.

Calyx small, bowl-shaped, wider than high. Dorsal cup shallow, with small concavity below for the reception of the column; plates pentagonal and spreading to the base of the radials. Radials five, about as wide as high, quite convex in their central part and spreading rapidly from the top of the basals. About two-thirds the top faceted for the reception of the plates above, notched on the inner margin. Anal plate somewhat larger than the others and somewhat conical above. Surface smooth, sutures very distinct on account of the convexity of the plates. This is a young specimen, and can not be specifically determined without the vault. It is referred to *Talarocrinus* rather than to *Dichocrinus*, on ac-

count of the thickness of the plates. The specimen belongs to Mr. G. K. Greene.

Locality.—Lanesville.

TALAROCRINUS SIMPLEX Shumard.

Plate XIII, figs. 7-7c.

*Dichorinus simplex* Shumard, Trans. St. Louis Acad. Sci., I, p. 74, pl. I, ff. 2a, b, 1857.

*Dichorinus constrictus* Meek and Worthen, Proc. Acad. Nat. Sci. Phil., p. 381, 1860, etc.

Wachsmuth and Springer's Description.—“A small species, the width of the calyx varying from 5 to 9 mm. Dorsal cup generally a little longer than wide, widest at the basi-radial suture or a little above, somewhat cylindrical along the medium portions, and generally contracting toward the arm bases. Plates thick, and without ornamentation or other markings; suture lines distinct, but not grooved.

“Basal cup large, semiglobose, extending to fully one-half the height of the calyx; the lower end slightly flattened, the central part excavated, forming a narrow circular pit of considerable depth; the salient angles at the upper margin quite obtuse, the re-entering angles toward the anal plate and the anterior radial comparatively sharp. Radials slightly differing in form, some being wider than others, but all, as a rule, longer than wide and narrowest at the top. The superior faces of the plates are directed obliquely inward, and the ends are but slightly truncated; they are excavated to one-half their width by the facets, which contain the costals and distichals. Anal plate generally wider at the bottom than the radials, but narrower at the top. Costals very minute. Distichals 1+10 in the calyx; of the same proportions as the overlying arm plates. Arms apparently ten, their structure and that of the ventral disk unknown.”

Localities.—Lanesville, Paynters Hill, Spergen Hill, Bloomington.

“This species has been heretofore referred to *Dichorinus*, with which, no doubt, it has some affinities; the presence, however, of a very minute costal, the form and arrangement of the distichals and succeeding brachials, show distinctly its relations with *Talarocrinus*.

The specimens vary considerably in size and somewhat in form; in most of them the sides of the calyx are evenly rounded, while in others they are contracted along the basi-radial suture. Meek and Worthen describe a specimen of this kind as a distinct species under the name of *D. constrictus*." (W. & S.)

Aside from these variations it should be remarked that the proportion of the calyx occupied by the basal plates varies with the age of the individual, being much less, relatively, in young specimens than in old ones, when it reaches to nearly one-half.

#### SYNBATHOCRINUS SWALLOWI Hall?

Plate XIII, fig. 11; Plate XIV, fig. 1.

*Synbathocrinus swallowi* Hall, Geol. Ia., I, pt. II, p. 672, pl. XVII, ff. 8, 9, 1858.

Calyx small, basin-shaped. The three basals form a ring around the columnar excavation, the five radial plates expanding rapidly upward, height about three-fourths the width, roughly quadrangular, except the two posterior ones, which have their two upper adjoining corners truncated, forming a notch and giving them a pentagonal outline. The top is faceted the entire width of the plate on the outer side, with a short ridge extending about half the width of the top of the plate; the inner edges of the plate. Lateral edges of the plate and the inner side turned up, the latter notched. At the posterior notch the edges of the plates are similarly turned up into the usual ridges, which extend inward almost like little teeth in some instances.

Localities.—Lanesville, Spergen Hill, Paynter's Hill.

The right lateral radial of one specimen is developed into a pentagonal piece by the elevation of its upper side into a pyramid, probably filling the place of the plate usually resting on it which had been removed by some accident.

Aside from the foregoing species there are plates, bases and portions of *Platycrinus*, *Actinocrinus*? and species probably belonging to other genera which can not be identified with sufficient certainty to be used here.



## PENTREMITES CONOIDEUS Hall.

Plate XXVI, figs. 32, 33.

*Pentremites conoideus* Hall, Trans. Alb. Inst., IV, p. 5, 1856.

See previous chapter by Miss Essie A. Smith.

Rowley has described two varieties of *Pentremites conoideus* from Lanesville. I do not have these specimens before me, and I quote here his remarks concerning them.

## PENTREMITES CONOIDEUS PERLONGUS Rowley.

Plate VII, fig. 7.

*Pentremites conoideus* var. *perlongus* Rowley, Cont. Ind. Pal., Pt. X, Vol. I, p. 87, pl. XXIX, f. 28, 1902.

"The greatest lateral diameter of the body is above the tips of the ambulacra, so that the form is almost barrel-shape, but with greater end diameter at the base. Like the typical form, this variety is strongly lobed; while from its extremely elongate shape, the plates are proportionately greater in length and less in width than in the broader forms. In outline this form is much like *Pentremiles elongatus* from the Burlington limestone."

"In the author's collection is a specimen from Flag Pond, Va., so contracted at the base as to give a truly elongate elliptical outline on side view.

"The type of this variety is from the Warsaw limestone at Lanesville, Indiana, and now in the collection of Mr. G. K. Greene."

## PENTREMITES CONOIDEUS AMPLUS Rowley.

Plate VII, figs. 8-8c.

*Pentremites conoideus* var. *amplus* Rowley, Cont. Ind. Pal., I, pt. X, p. 88, pl. XXIX, ff. 31-34, 1902.

"The width of these specimens is quite as great as the length, and the greatest lateral diameter is midway the body, giving a Granatocrinoid form to the fossil."

Locality.—Lanesville.

## TROOSTOCRINUS.

Troostocrinus was proposed by Shumard in 1865 for *Pentremites laterniformis* and other fusiform pentremites, in a foot-note to that species, which reads: "There appear to me good reasons for removing this and other sub-fusiform species, as *Pentremites Reinwardtii*, *P. lineatus*, *P. bipyramidalis*, *P. wortheni*, and perhaps *P. grosvenori*, from among the *Pentremites* and grouping them together as a separate subsection under another name. These and allied forms are remarkable in their slender, subfusiform shape, linear pseudambulacral fields, triangular base and summit structure. These external differences would seem to imply corresponding modifications in the internal economy of the animals of more than specific importance. If, from a thorough study of such species, it shall be deemed advisable to separate them from the genus *Pentremites*, I would propose the name TROOSTOCRINUS for the group, in honor of the late Dr. Gerard Troost, of Tennessee, among the earliest pioneers in American geology and palæontology."

In 1868 Meek and Worthen proposed *Tricoelocrinus* for the other extreme of the group with the implication that *T. woodmani* should be considered as the genotype.

After an exhaustive study of the Pentremites, Dr. Hambach, of St. Louis, revised the whole classification and grouped both the above genera and *Metablastus* of Etheridge and Carpenter in a single genus, and proposes the term *Sacoblastus* for it. This classification was made after an extended study of the pentremites, and is based on the apical structure, as he found the external form was of only specific value.

His definition of the genus is as follows:

"General form of the body pyriform, compressed cylindrically, or club-shaped. Ambulacra narrow and linear, generally, sunk into the fork piece sinus so that the surface does not touch the upper margin of the fork piece sinus. Lower part of the body shows three distinctly depressed areas; the amount of depression varies in different species. Interambulacral surface smooth or very finely striated. Summit opening never closed save by the ambulacral integument. Genital openings ten, of a slit-like appearance, on account of the orifice opening obliquely. Anal opening

so far below the genitals that in large specimens it is almost  $\frac{1}{4}$  inch below the summit, and as far as known not covered. All specimens which I have had an opportunity to examine (over six hundred) did not show any sign of a covering. Column triangular. This genus comprises *Troostocrinus*, *Tricoelocrinus* and *Metablastus*, and to show the gradual transformation from one to the other I have given good figures of all our American species on plate IV. All described specimens are from the Warsaw limestone or below from the lower Subcarboniferous rocks."

In his revision he states that "All names ending in 'Crinus' are dropped" and proposes new ones in their stead. This is an unfortunate act, because of its violation of the rules of priority. While it might be pleasant to have appropriate or fitting names for genera and species, it is better to stick to rules of priority and thus have some escape from the chaotic confusion which would certainly result in the discarding of all names which might not suit the fancy of reviewers.

If these three genera are grouped together it is not, perhaps, beyond question whether *Troostocrinus* or *Tricoelocrinus* should be used. It is unfortunate that Shumard appended the footnote to *P. laterniformis*, thus implying that it was intended as the genotype, and which alone has been retained under *Pentremites*. However, his delineation of the characters of the group and the list of species referred to it leave no possible doubt as to his clear understanding of the salient characters of his proposed sub-genus, and the species to be referred to it. Add to this the fact that no genotype is signified, and it should be sufficient reason for retaining his name. In addition to this, it offers some little redress for the great wrong suffered by Dr. Troost at the hands of some of his contemporaries. Should it not be retained, *Tricoelocrinus* would have to be used and *T. Woodmani* would be the type of the genus.

The material at hand is not sufficient, or, for the most part, well enough preserved to warrant extended observations on the classification of the group. It is to be regretted that Hambach gave no detailed discussion of his reasons for combining these genera into one, and as a consequence we are obliged to follow Etheridge and

Carpenter's classification which seems to be based upon careful observation of fundamental characters, until Hambach shows that there is reason for abandoning it.

METABLASTUS WORTHENI Hall.

Plate XIV, figs. 8-9b.

*Pentremites wortheni* Hall, Geol. Rep. Ia., I, pt. II, p. 606, pl. XV, f. 1, 1858.

"Body elongate subfusiform; length of base and distance from base of radials to base of pseudo-ambulacral area, and length of the latter, about equal to each other. Base triangular. Basal plates very gradually spreading; upper margins concave for the reception of the radials. Radial plates long, narrow, almost linear; branches lanceolate. Interradial plates very small, acutely lanceolate, reaching very nearly to the summit. Pseudo-ambulacral areas very narrow, linear, extending downward about half the length of the radial plate, and one-third the entire length of the body. Each of these areas contains about thirty-five pore pieces on each side."

"Surface finely striated longitudinally and transversely."

Localities.—Lanesville, Bloomington.

According to Dr. Hambach this is a very variable species, the form probably depending upon the age of the particular individual. This author includes under this species *Metablastus nitidulus*, *M. varsoviensis*, *M. wachsmuthi* and *Troostocrinus grosveneri*.

TRICOELOCRINUS MEEKIANUS Etheridge and Carpenter.

Plate XIV, figs. 7-7b.

*Tricoelocrinus meekianus* Etheridge and Carpenter, Cat. Blast. Geol. Dept. Brit. Mus. Nat. Hist., p. 208, pl. XVI, ff. 17, 18, 1886.

Original description.—"Calyx slender, elongated pyramidal; summit very small and very much contracted; base with shallow lateral excavations; section pentagonal, with straight or flat sides; periphery rather nearer the base than the summit. Basal plates forming a low triangular cup, with the three carinae truncated, and not projecting below the central triangular surface which

bears the facet for the columnar attachment. Radial plates with slightly converging lateral margins; bodies much shorter than the limbs, and moderately carinate, the lateral basal excavations extending but little on their surfaces; limbs narrow with flat sides, not sloping at a high angle; sinuses three-quarters the length of the calyx with high sides; interradial sutures not in concavities. Ambulacra rather deeply sunken. Hydrospires unknown; Spiracles apparently mere slits only. Ornament not preserved."

Localities.—Spergen Hill, Paynters Hill?, Bedford, Bloomington.

There is a considerable difference in form between the specimens figured and the figure by Etheridge and Carpenter, but it is merely the difference in robustness of age. It has the nearly flat sides, truncated base and other characters separating it from the above species which is inserted for comparison. It may be found in the Salem limestone, but has not been as yet. It was described from the Harrodsburg limestone at Salem.

The stem of *Tricoelocrinus* is triangular instead of round, as stated by Etheridge and Carpenter.

#### TRICOELOCRINUS WOODMANI Meek and Worthen.

Text figs. 4, 5.

*Pentremites obliquatus* Roemer, Archiv. fur Naturgesch., Jahrg. XVII, p. 367, taf. VIII, ff. 11a, b, 1851.

Body large, pyriform, nearly flat below. Ambulacral areas very long, three-fourths the length of the individual, very narrow, deeply sunken beneath the surface of the body. About seventy-five poral pieces on a side. Radial pieces very long, quadrangular outwardly, terminating in points above the oral aperture. The two plates, which are truncated below to form two of the three excavations in the base, have the ambulacral angle extending downward from the end of the area a distance equal to one-third its length. They are then almost flatly truncated, the ridges connecting the right posterior to those on either side may be so faint as to be scarcely noticeable; one ridge on the other plate is usually quite prominent. On this account the triangular columnar articulation is usually a little eccentric toward the ante-

rior. The basals form a shallow, ten-sided, irregular saucer, with three prominent ridges reaching to the center. Plates quadrangular and hexagonal, the three sutures falling in the three basal excavations. These three depressions of the base are shallow but distinct, tending to truncate the entire base. The surface of the specimens are covered with minute striae roughly parallel to the edges of the plates. Oral opening comparatively small. Genital openings quite small, opening beneath the tips of the radial (?) plates. Anal opening large, situated well down below the apex.

Localities.—Salem, Harrodsburg limestone.

#### ARCHÆOCIDARIS NORWOODI Hall.

Plate XIV, figs. 6-6a; Plate XVIIA, figs. 5-5f.

Plates mostly hexagonal, wider than long, and of small size, Articulating process subtubuform in unweathered and unworn specimens, separated from the annulation by a pronounced furrow. Annulation distinct, being merely the top of the cylindrical elevation with elevated lines on the side which run out over the platform at the base and fade out before reaching its edge. Similar lines radiate from the margin of this platform across the excavated flattened surface of the plate toward the elevated nodose margins, but generally fade out before reaching it. These lines are usually fasciculated. The lateral margins may possess one, two, or three, or more rows of small crowded nodes, but the longer margins never have but a single row. Spines smooth except for extremely fine longitudinal lines, which extent their full length, and some indications of incipient spinules. Rarely are these spinules large enough to be noticed by the naked eye. They are mere longitudinal elevations, over which the fine surface lines extend. The annulation is strongly nodose in well preserved spines. Teeth, probably of this species (as the remains of no other have been seen) occur at Spergen Hill and are shown in the plate.

Localities.—Spergen Hill, Paynters Hill, Harrodsburg.

These specimens differ from *A. Norwoodi* in having the elevation and platform of the plates ornamented and in the relative smoothness of the spines.

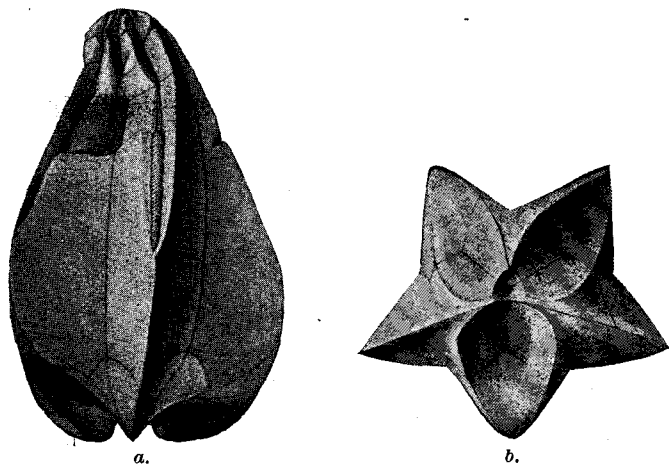


Fig. 4. A, lateral view, showing anal opening. B, basal view, showing the deep angles of the sides and the sharply produced keels and the sharply defined excavations of the base. In these characters it differs from *T. meekianus*.

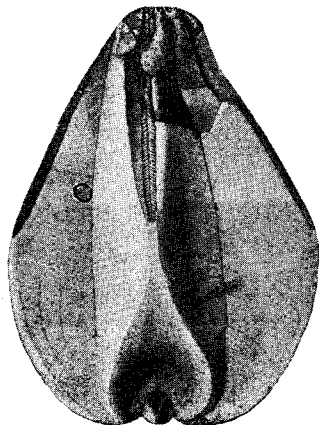


Fig. 5. Lateral view, showing side nearly opposite to Fig. 4. The description and figures of this species are included here for comparison with *T. meekianus*.

**TRICOELOCRINUS WOODMANI** Meek and Worthen.

## HOLOTHURIAN SPICULES?

Plate XIX, figs. 9-17.

Spicules resembling sand burs or stellate sponge spicules, but which seem likely to be Holothurian spicules abound in the Harrodsburg and Bloomington localities, with an occasional one at Spergen Hill and Paynter's Hill. They seem to be more abundant at Harrodsburg than anywhere else.



## VERMES.

By J. W. BEEDE.

### SPIRORBIS IMBRICATUS Ulrich.

Plate XVII, figs. 5-5c.

*Spirorbis imbricatus* Ulrich, U. S. Prof. Pap. 36, p. 34, pl. IV, f. 10, 1905.

Shell spirally coiled at first, rather small, enlarging rapidly and becoming free, twisted trumpet-shaped in old individuals. The shell is ornamented with greatly produced concentric lamellae, which indicate the former location of the flaring orifice. There are smaller concentric marks between the large lamellae.

Localities.—Paynters Hill, Harrodsburg, Bedford.

This species is intimately associated with *S. annulatus* Hall, and the more slender small specimens with the lamellae somewhat worn are separated from it with difficulty. The points of distinction between the two are that *S. annulatus* has the lamellae much less developed and after the first whirl or two is passed it is cylindrical and always very slim, and when old develops into a cylindrical corkscrew, while the present species is more robust, enlarges more rapidly and when old develops into a twisted trumpet, with very highly developed scale-like lamellae, indicating growth stages.

### SPIRORBIS ANNULATUS Hall.

Plate XVII, fig. 6; Plate XXVI, fig. 30.

*Spirorbis annulatus* Hall, Trans. Alb. Inst. IV, p. 34, 1856.

"Shell planorbicular, more or less ascending, irregular spiral; spire composed of about three turns, which are contiguous or more or less disconnected; umbilical side more or less deep and regular, according to the regularity of the spiral; surface ornamented with strong annulations, with finer striae between.

"Diameter from .062 to .25 of an inch." (Hall.)

Localities.—Paynters Hill, Spergen Hill, Harrodsburg, Bedford, Bloomington, Ellettsville, Stinesville, Romona.

"This species attains a rather larger size than is common with those of the genus. The coiling of the tube is very irregular, but always dextrally ascending from a small base of attachment, although the specimens are invariably found free. The annulating striae are strong, raised and lamellose, and form a very good distinguishing feature of the species." (Whitfield.)

It should be noted here that many specimens are found attached to bryozoa and corals and occasionally shells. The lamellae are less strong and less imbricating than in the preceding species and it is more cylindrical.

#### SPIRORBIS NODULOSUS Hall.

Plate XXVI, fig. 31.

*Spirorbis annulatus* var. *nodulosus* Hall, Trans. Alb. Inst., IV, p. 34, 1856.

"Shell in form like the preceding; last volution strongly deflected, volutions subangular, marked by oblique striae or ridges, which become strongly nodulose on the umbilical side, and particularly towards the aperture." (Hall.)

Localities.—Spergen Hill, Paynters Hill, Harrodsburg.

"The nodose character of this species is a strong distinguishing feature, and is entirely unlike the surface structure of the preceding one, being composed of oblique rows of thickened nodes, not capable of being formed by a modification of the distant, straight, encircling lines of the surface of that one, therefore I see no impropriety in classing it as a distinct species. It possesses about two or two and a half volutions, the latter part of the outer one being deflected to nearly an upright position and is free and cylindrical. Both these species in nearly every case show indications of having been fixed to some foreign substance when living and young, but are always, so far as I am aware, found loose in the rock. It would seem probable that they had been attached during life to some perishable substance, as a plant, which on decomposing had freed the tubes and allowed them to fall to the bottom of the water in a free state."

The specimens of this species have also been found attached. They are of very much more rare occurrence than *S. annulatus*, and have not been found in the "corkscrew form."

## ORTONIA BLATCHLEYI N. SP.

Plate XIX, fig. 8.

Tubes quite small, rather crooked trumpet-shaped, enlarging gradually, solitary. The shell is moderately thin, with short, coarse, imbricating annulations with smaller ones between in specimens not waterworn; attached the entire length. The base is acute. Our specimens are small and attached to *Monilipora beecheri* Grabau.

Locality.—Bedford.

This fossil lacks the longitudinal striations of *T. Cornulites* and are attached throughout their entire length. In these points it agrees with Nicholson's genus *Ortonia* and is referred to it. There is no Carboniferous worm in America with which it may be confounded.

## DESCRIPTION OF THE BRYOZOA OF THE SALEM LIMESTONE OF SOUTHERN INDIANA.

BY E. R. CUMINGS.

Very few Bryozoa have ever been described from the famous oölitic limestones of Indiana, and those that have been described have found scant recognition in the literature. The ample list of species presented here, some of them new to science, and many of them well known forms in the equivalent formations of Illinois and Kentucky, will be a surprise to those geologists and paleontologists who have gained the impression from the famous Spergen Hill fauna of Hall and Whitfield that the Indiana oölitic contains only small dwarfed fossils. No better preserved fossils have ever been studied by the writer than these exquisite Fenestellids and other Bryozoa from the Dark Hollow quarries of Bedford—a town famous for its building stone, but hitherto unknown as a collecting ground for abundant and beautifully preserved fossils.

The Bryozoa described herein are from the top of the Salem formation and are contained in an exceedingly soft, loose-grained, greatly decomposed limestone, of such sort that it is possible to obtain free from the matrix portions of the fronds of practically all the species. The very wealth and wonderful preservation of the material has made the study replete with difficulties, because of the presence of characters that only the most perfectly preserved material could show, and which have therefore probably hitherto escaped notice, and because of the abundance of variations of all sorts.

A glance at the descriptions that follow will show that the fauna contains a number of forms characteristic of the Keokuk formation, and which have not hitherto been listed from above that horizon. The Warsaw species described from Bedford show differences from their equivalents in Illinois, perhaps dependent upon the exceptionally favorable conditions which must have obtained at the Indiana locality.

The distribution of this Bryozoan fauna in Indiana has not yet been adequately determined. Many of the species have been seen

at Bloomington, and some at Stinesville and Ellettsville. The localities farther south have not afforded many Fenestellidae. This is perhaps more due to the sort of preservation that obtains at Spergen Hill and other southern localities than to an actual absence of Fenestellids from the waters. *Hemitrypa Proutana* is usually present in these localities and with it a *Polypora* or two.

Where the stunted fauna comes in, as at Harrodsburg, Fenestellid Bryozoa are either absent or in such small fragments as to be nearly unidentifiable. At Harrodsburg small species of *Rhomopora* are fairly common.

Class BRYOZOA Ehrenberg.

Order GYMNOLAEMATA Allman.

Suborder CRYPTOSTOMATA Vine.

Genus FENESTRALIA Prout.

"Zoarium as in Fenestella, but with four rows of apertures, two on each side of the prominent median keel."

FENESTRALIA SANCTI-LUDOVICI Prout.

Plate XXVII, figs. 1-1a.

Trans. St. Louis Acad. Sci., I, p. 235, pl. 15, Figs. 1-1a.

"Zoarium a large flabelliform expansion. Branches 9.5 to 11.5 in one cm., rather slender and unequal, somewhat rigid, strongly carinated, the aperture bearing surfaces either flat or slightly convex; average width of branches 0.6 mm., increasing from 0.5 to 0.7 or 0.8 mm. between the bifurcations. Dissepiments rounded, depressed, expanding but little at their ends, about two-thirds the width of the branches. Fenestrules oblong sub-quadrangular or oval, their width varying from one-fourth to one-half the length; about six in one cm. longitudinally. Carina strong, rounded, dilating into prominent elongated tubercles at intervals of 1 mm. Zoëcia in four ranges, two on each side of the carina. Apertures sometimes alternating, usually opposite, those of the lower ranges opening obliquely or directly into the fenestrules and often obscured by those of the upper rows. \* \* \* There are six or seven apertures in each row to a fenestrule, one of them opposite each dissepiment. The apertures are of medium size, surrounded

by a thin peristome, their diameter or a little more apart, with eighteen in 5 mm.

"On the reverse the branches are narrowly rounded, smooth or finely granulose, have sloping sides, are straight or slightly zigzag, and appear much thicker than on the opposite side." \* \* \* (Ulrich, Geol. Surv. Ill., VIII, pp. 604, 605.)

Bedford, Indiana, rare.

Indiana University collection.

#### FENESTRALIA COMPACTA Ulrich.

Plate XXVII, fig. 2.

Geol. Surv. Ill., VIII, p. 605, pl. 59, Fig. 1.

Zoarial characters similar to those of *F. St.-ludovici*. Branches narrower, 11.5 to 12.5 to the cm. Nodes on the keel inconspicuous or wanting. Large nodes on the reverse. Dissepiments depressed, strong, rounded. Fenestrules 8 in one cm.

Bedford, Indiana, rather common.

Indiana University collection.

#### Genus FENESTELLA Lonsdale.

Murchison's Silurian System, p. 677.

Zoaria flabellate or infundibular, poriferous on one side; branches straight, or sometimes somewhat flexuous, connected at frequent intervals by non-poriferous cross-bars, called dissepiments. Zoecia in two rows, one on each side of a median keel or row of spines or nodes. Reverse of branches usually striate or granular.

The original definition of this genus by Lonsdale restricts it to forms having the zoecia on the *outside* of an infundibular zoarium—such forms as *F. Milleri*, which have recently, and the writer believes incorrectly, been placed in a separate genus, *Semicoscium*. Lonsdale in the Geology of the Ural Mountains greatly widened his definition of *Fenestella*, making it include forms now placed in several more restricted genera. His original intent, however, was clearly to erect a genus for such forms as *F. Milleri*, having the zoecia on the *outside* of the zoarium. By a strange irony of fate the genus has recently been restricted to forms having the zoecia on the *inside* of the zoarium. The writer has made it

clear in his studies of the development of Paleozoic Bryozoa\* that the classification of the Fenestellids is in an unsatisfactory condition, and that a satisfactory solution of the difficulties must be sought in the ontogeny of the various forms now referred to *Fenestella* and its related genera. The Mississippian forms are nearly all flabellate, hence they are in especial need of this sort of study in order to determine their true relationships to the *Fenestella* and *Polypora* groups as defined by the writer.† It is probable that a genus should be erected to receive persistently flabellate forms.

For the present the writer follows the customary usage in this country, which we owe to Mr. E. O. Ulrich, and which considers *F. plebeia* McCoy as the genotype.

#### FENESTELLA RUDIS Ulrich.

Plate XXVII, fig. 3-3b.

Geol. Surv. Ill., VIII, p. 537, pl 49, Figs. 3-3d.

Zoarium a large flabellate expansion. Branches flexuous, stout, about 0.3 mm. in diameter, 16 to 18 in one cm., approaching each other somewhat at the dissepiments. Fenestrules oval in the younger portions of the zoarium, rounded in the older portions; 10 to the cm. Zoecia large, peristomes inconspicuous; 4 to 5 zoecia to the fenestrule, 22 in 0.5 cm. Carina medium strong and carrying a row of large spines 0.5 mm. or more apart. In weathered specimens the carina appears much narrower and sharper. Reverse of branches rounded, and with a number of large low spines to the fenestrule, especially at the angles of the fenestrules. Mr. Bassler would consider this a good variety of *F. rudis*.

Bedford, Indiana, rather common.

Indiana University collection.

#### FENESTELLA COMPRESSA var. ELONGATA n. var.

Plate XXVIII, figs. 1-1b and 2-2c.

Zoaria consisting of flabellate expansions of very lax growth. Branches small, narrow, rounded, sometimes slightly flexuous, about 0.15 to 0.25 mm. in diameter, and 12 to 16 to the cm. Fen-

\*Am. Jour. Sci., Vol. xvii, January, 1904.

†*Op. cit.*

estrules oblong to quadrate, 7 to 9 in 1 cm., the length of a fenestrule varying from 0.8 to 1.3 mm. and the breadth from 0.3 to 0.5 mm. On the reverse the quadrate or rectangular appearance of the fenestrule is much more pronounced than on the obverse; hence on the obverse they frequently appear oval or elliptical. Zoëcia rather small, 0.075 mm. in diameter, without pronounced peristomes, slightly indenting the fenestrules; 5 or 6 zoëcia to the fenestrule. The carina is high and narrow and bears an occasional conspicuous spine. Reverse of branches rounded, either smooth or with a number of spines to the fenestrule, which are sometimes very long and sharp.

Bedford, Indiana, not common.

Indiana University collection.

#### FENESTELLA EXIGUA Ulrich.

Plate XXVIII, figs. 3-3a.

Geol. Surv. Ill., VIII, p. 545, pl. 51, figs. 1-1a.

Zoarium forming large flabelliform expansions. Branches somewhat flexuous, 18 to 20 to the cm., 0.15 to 0.45 mm. in diameter. Fenestrules oval, 12 to 14 to the cm. Zoëcia small, from 4 to 5 to the fenestrule. Carina narrow, elevated, carrying 2 or 3 low spines to the fenestrule. Reverse of branches rounded, with a strong node at each end of the dissepiments, and a few nodes scattered irregularly over other portions of the branches.

Bedford, Indiana, rather rare.

Indiana University collection.

Normal range Warsaw.

#### FENESTELLA MULTISPINOSA Ulrich.

Plate XXIX, figs. 1-1e.

Geol. Surv. Ill., VIII, p. 540, pl. 50, figs. 3-3d.

Zoarium flabellate, expanding rapidly because of the frequent bifurcation of the branches. Branches straight, 0.3 to 0.5 mm. in diameter; 18 to 20 in one cm. Fenestrules round to oval in the basal region, rectangular near the growing margin; 13 to 15 in one cm. Zoëcia about 0.1 mm. in diameter, 3 to 4 to the fenestrule; in the older portions of the zoarium usually operculate. Obverse



with a row of small nodes on the not very prominent carina, and with the carinate dissepiments often elevated into a distinct spine which is sometimes very prominent. Reverse granular-striate in the younger portions and strongly granular in the older portions of the zoarium. The large regularly arranged nodes shown in Fig. 1-c have not been observed in any other specimen. This latter specimen may prove to belong to a distinct species, but for the present I prefer to include it here.

Bedford and Bloomington, Indiana, very abundant.

Indiana University collection.

Normal range Keokuk.

**FENESTELLA TENAX** Ulrich.

Plate XXX, fig. 1; XXXI, figs. 1-1b.

Bull. Denison University, IV, p. 71.

Zoarium consisting of very delicate, closely arranged, rounded branches, bifurcating at long intervals; 28 to 30 branches to the cm. Diameter of branches 0.15 to 0.45 mm., the latter measurement being just below a bifurcation. Fenestrules oval, indented by the zoecia; 22 to 23 to the cm. Zoecia very small, with prominent peristomes. Three zoecia to the fenestrule, 26 in 0.5 cm. Carina usually elevated and narrow, often carrying a row of small spines, one to each zoecium. Reverse granular-striate. Dissepiments very narrow, slightly expanded at their junction with the branches.

Bedford, Indiana, rather common.

Indiana University collection.

Normal range Waverly to Chester.

**FENESTELLA TENAX** var. **MULTINODOSA** n. var.

Plate XXXI, figs. 2-2a.

Dimensions the same as in *F. tenax*, but with a row of small spines along the carina, from 4 to 5 to the fenestrule, and arranged in a zigzag line. Only a few specimens of this form have been seen.

Bedford, Indiana, very rare.

Indiana University collection.

**FENESTELLA SERRATULA** Ulrich.

Plate XXX, figs. 2-2c, 3-3a.

Geol. Surv. Ill., VIII, p. 544, pl. 50, figs. 5-5c.

Zoarium a foliar expansion. Branches small, straight, bifurcating at rather frequent intervals, 0.15 mm. to 0.45 mm. in diameter; from 22 to 26 to the cm. Fenestrules oval to rectangular, 15 to 20 to the cm. Zoecia small, 2 to 3 to the fenestrule, 22 to 0.5 cm. Carina line-like, or when perfect fairly prominent, surmounted by a row of small, rather sharp spines, one to each zoecium. Reverse rather strongly striated and granular. Dissepiments very narrow, slightly expanded at their junction with the branches, slightly carinate on the obverse. A very variable species.

Bedford, Indiana, common.

Indiana University collection.

•Normal range Keokuk to Chester.

**FENESTELLA TENUISSIMA** n. sp.

Plate XXX, fig. 4.

Only a few specimens of this delicate form have been seen. It strongly resembles *F. perminuta* of the Lower Coal Measures. The excessive tenuity of the dissepiments and small size and wide separation of the zoecia place this form in strong contrast with any of its associates in the Salem limestone. Branches flexuous, very narrow, 0.15 to 0.2 mm. in diameter; 20 to 24 to the cm. Fenestrules rectangular, indented by the zoecia; 13 fenestrules to the cm. Zoecia very small, separated by more than their diameter, and with prominent peristomes. Three to four zoecia to the fenestrule. Dissepiments very narrow, striated, slightly expanded at each end. Reverse of branches finely striated. Carina very narrow and low, with an occasional low spine.

Bedford, Indiana.

Indiana University collection.

**FENESTELLA SERRATULA** var. **QUADRATA** n. var.

Plate XXXI, figs. 3-3a.

Zoarium flabellate. Branches round, bifurcating at long intervals, 0.15 mm. in diameter, 20 to 21 to the cm. Fenestrules quad-

rate to oblong, 15 to the cm. Indented by the zoecia. Dissepiments about one-half as wide as the branches, slightly expanded at their junction with the latter, conspicuously striate. Zoecia small, distant, with moderately prominent peristomes; 3 or 4 to the fenestrule. Carina scarcely at all elevated and without spines. Reverse faintly granular-striate. The strikingly quadrate appearance of the fenestrules is the chief characteristic of this variety. An extreme form of *F. serratula*.

Bedford, Indiana, common.

Indiana University collection.

Genus *HEMITRYPA* Phillips.

Paleozoic Fossils, p. 27.

"Zoaria funnel-shaped or undulating foliar expansions; branches rigid. Zoecia in two ranges, their apertures separated by a moderately developed keel. The latter is elevated at regular intervals into small pillars, which, when the superstructure they support is worn away, appear as spine-like prominences. The superstructure consists of straight or zigzag longitudinal bars, of which one is placed over each branch upon the row of pillars, and another usually somewhat thinner, suspended midway between the branches. These bars are then connected by transverse processes, so as to leave regular, small, generally hexagonal openings, corresponding in number and position with the zoecial apertures beneath them." (Ulrich, Geol. Surv. Ill., VIII, p. 396.)

*HEMITRYPA PROUTANA* Ulrich.

Plate XXXII, figs. 2-2b.

*Fenestella Hemitrypa* Prout.

Geol. Surv. Ill., VIII, p. 560, pl. 57, figs. 1-1c.

Trans. St. Louis Acad. Sci., I, p. 444, pl. 17, figs. 4, 4a.

"Zoarium a large flabellate or semi-infundibular expansion, more or less undulated toward the free margins. Obverse or inner side protected by a delicate network, formed by the union of longitudinal and transverse bars. The former consists of two kinds, a slightly stronger and more prominent set, which are developed directly over the center of the branches and united to

them by short supporting pillars. These may be called the *principal* bars. A second set, which alternates with the principals and may be known as the *secondary* bars, are suspended over the space between the branches. The network is completed by a set of short transverse bars [scalæ]. \* \* \* Measuring transversely, about twenty-six rows of interstices occur in 5 mm.; longitudinally about twenty-four. One to three small denticles sometimes project from the bars into the interstices. When this network has been denuded \* \* \* the obverse face of the branches is seen to be ridge-shaped, from 0.2 to 0.32 mm. wide, and generally 26 in 1 cm. The median carina is neither sharp nor prominent, but carries small nodes (the broken pillars that support the superficial network) at intervals corresponding with the length of the zoecia. Dissepiments very short, depressed, about half as wide as the branches. Fenestrules long-oval, small, about 0.3 by 0.1 mm., and 18 or 19 in 1 cm. Zoecia in two ranges, 23 or 24 in 5 mm., with small, widely separated, circular apertures, and elevated peristome.

"On the reverse the branches and dissepiments are on the same plane, usually ridge-shaped, forming quadrangular fenestrules of greater width than on the opposite face. On mature examples the branches are smooth or very finely granular. On young ones they are faintly striated." (Ulrich, *loc. cit.*)

Bedford, Bloomington, Spergen Hill, Lanesville and Edwardsville, Indiana, rather common.

Collections of American Museum, National Museum and G. K. Greene.

Normal range Keokuk to St. Louis.

#### HEMITRYPA PROUTANA var. NODODORSALIS n. var.

Plate XXXII, figs. 1-1c.

Dimensions and characters of the superstructure same as in *H. Proutana*, but with a conspicuous node at each angle of the fenestrules on the reverse; and branches and dissepiments more rounded than in that species. This is the commonest *Hemitrypa* at Bedford.

Bedford, Indiana, common.

Indiana University collection.

## HEMITRYPA BEEDEI n. sp.

Plate XXXII, figs. 3-3c.

Zoarium and infundibular expansion attaining a size of several cm., undulating. Branches rigid of very uniform breadth, scarcely departing from 0.3 mm. except just above and just below a bifurcation. Bifurcations remote, so that the frond expands very slowly. There are 24 branches to the cm. Fenestrules very narrow in fully developed portions of the zoarium, almost slit-like, especially as seen from the reverse, 19 to 20 to the cm. The ratio of length to breadth may be as great as 7 to 1. The normal breadth of a fenestrule is 0.125 to 0.15 mm., and the length 0.3 to 0.35 mm. Dissepiments very short, depressed, and where the fenestrules are narrowest, scarcely visible at all. They have much the same appearance on both the obverse and reverse.

Superstructure consisting of pentagonal and hexagonal interstices, 24 in 0.5 cm., both longitudinally and transversely; strongly indented by three or four knob-like tubercles, giving them a decidedly floriform appearance. The primary bars are elevated above the general level of the interstices, forming a rather conspicuous ridge over each branch.

The reverse of this species is very characteristic. The branches are flattened and strongly marked by five or six granulose striae. In this respect the resemblance to *H. peristriata* is very close, but the lines of nodes are lacking. Other differences from *H. peristriata*, its nearest ally, are the floriform, polygonal interstices, and the dimensions; the latter species having 20 to 22 branches and 14 or 15 fenestrules to the cm., whereas the present species has 24 branches and 19 to 20 fenestrules to the cm.

Bedford, Indiana, rare.

Indiana University collection.

## Genus POLYPORA McCoy.

Synopsis of the Carboniferous Fossils of Ireland, p. 206.

Zoaria similar to *Fenestella* in general shape and either infundibular or flabellate. Zoecia on one side of the branches, in more than two rows. Median keel lacking. A row of tubercles sometimes occupies the median line of the obverse of the branches. Dissepiments non-poriferous. Reverse smooth or striate.

The relationships of this genus have been discussed by the writer in his memoir on the Development of Paleozoic Bryozoa.\* It was shown there that in its ontogeny it is very different from *Fenestella*, and probably with its associates entitled to rank in a separate family. The above diagnosis follows the present usage in this country, but will need some modification when the development of the forms now referred to the genus is made known.

POLYPORA SIMULATRIX Ulrich.

Plate XXXIII, figs. 1-1b.

Geol. Surv. Ill., VIII, p. 589, pl. 59, figs. 4-4b.

Zoarium a very large wavy flabellate expansion, the largest seen being 18 cm. wide and 10 cm. long. Branches large, slightly sinuous, diameter varying considerably, from 0.6 to 1.25 mm., the average being about 0.75 mm. On the obverse the branches are broadly rounded or flattened, while on the reverse they descend rather abruptly into the fenestrules on either side and are often considerably flattened on the back. Reverse very finely granular. Eight to ten branches to the cm. Fenestrules suboval to rectangular, the latter appearance is especially characteristic of the reverse; 2.5 to 4.5 mm. long, 0.3 to 0.8 mm. broad. Zoecia large, 0.1 to 0.15 mm. in diameter; in 3 to 5 alternating rows. Peristomes well developed, especially in the older regions of the zoarium, where they are very prominent. In the younger portions of the zoarium the zoecia are conspicuously elliptical in shape, with their longer axis in the direction of the branch, or, in the case of those in the outside rows, oblique to the direction of the branch. In the older portions of the zoarium the zoecia appear more rounded. There are normally seven zoecia in a row to the fenestrule; 15 in 0.5 cm. Dissepiments slender, striated, 0.15 to 0.45 mm. in diameter scarcely expanded at their ends, sometimes running rather obliquely from branch to branch.

This is one of the largest polyporas in the Mississippian rocks, being fully as large as *P. Halliana* and *P. Maccoyana*, and differing from both in the absence of granules on the obverse, and in

\*Am. Jour. Sci., Vol. xvii, January, 1904.

the conspicuous peristomes, and in the elliptical apertures and striated dissepiments.

Bedford and Bloomington, Indiana, common.

Indiana University collection.

Normal range Keokuk.

*POLYPORA STRIATA* n. sp.

Plate XXXIII, figs. 2-2a.

Zoarium a large flabellate expansion. Branches rigid or slightly flexuous, 0.4 to 0.9 mm. in diameter, 11 or 12 to the cm., obverse rounded and spinose, reverse flattened, distinctly striated. Fenestrules oval to subquadrate, 0.6 to 0.9 mm. long by 0.3 to 0.6 mm. wide, 6 to 8 to the cm. Zoecia in two or three ranges, somewhat irregularly disposed, small, about five in a row to the fenestrule. Dissepiments narrow, round on the reverse, 0.15 to 0.2 mm. in diameter, expanded at their junction with the branches (especially on the obverse), and slightly carinate on the obverse. On the obverse there are one or two strong spines to the fenestrule. The reverse is marked by well defined, longitudinal striae, except in the older part of the zoarium.

Bedford, Indiana, rare.

Indiana University collection.

*POLYPORA INTERNODATA* n. sp.

Plate XXXIV, figs. 1-1a.

Zoarium a flabellate expansion. Branches somewhat sinuous, flattened on the reverse, rounded on the obverse, varying considerably in diameter—from 0.25 to 0.75 mm. Ten to twelve branches to the cm. Dissepiments short, very narrow, 0.2 mm. in diameter, striated on the obverse and depressed; about on a level with the branches on the reverse, and each dissepiment bearing a stout, round spine, midway between the branches. On the reverse the dissepiments appear shorter than on the obverse. Fenestrules varying greatly in size and shape, usually oval to elliptical, from 0.2 to 0.6 mm. wide and from 1.0 to 1.5 mm. long; 7 to 8 fenestrules to the cm. Zoecia large (0.15 mm. in diameter), round, with

prominent peristomes; and in two to four ranges, four in a row, to the fenestrule, 14 to the half cm. The prominent spines on the dissepiments will distinguish this species from all others.

Bedford, Indiana, rare.

Indiana University collection.

**POLYPORA BISERIATA** Ulrich.

Plate XXXIV, figs. 2-2b.

Geol. Surv. Ill., VIII, p. 592, pl. 60, figs. 4-4b.

"Zoarium a slowly expanding, irregular, more or less undulating, foliar network, from four to eight cms. in height. Branches closely approximated, 17 to 19 in 1 cm., slender, averaging 0.5 mm. in width, but increasing from 0.4 to 0.7 mm. before bifurcation, which takes place at intervals of from 5 to 14 mm. Their periferous surface is nearly flat or slightly elevated centrally, where a row of prominent spines or nodes about 0.45 mm. apart, almost give the impression of a median keel. Dissepiments short, depressed, one-half or less than one-half the width of the branches. Fenestrules small, suboval, about 14 in 1 cm. Zoecia in two alternating ranges, increasing to 3 at a point 2 or 3 mm. below the branch divisions. Apertures large, 0.15 mm. in diameter, direct, with prominent peristome, 17 or 18 in 5 mm., their diameter or less apart, often closed by an opercular cover of the usual type. On the reverse the branches are rather broadly rounded, somewhat channeled below the bifurcations, and either smooth or very finely striated; the dissepiments thin and not depressed, and the fenestrules sub-quadrate." (Ulrich, *loc. cit.*)

The Indiana specimens of this species have 15 to 16 branches and 12 fenestrules to the cm., but in other respects correspond very closely to the description given above.

Bedford, Indiana, rather rare.

Indiana University collection.

Normal range Warsaw.

**POLYPORA MACCOYANA** Ulrich.

Plate XXXIX, fig. 1; Plate XL.

"Zoarium a large, flabellate, slowly expanding frond. Branches 6 to 8 in 1 cm., strong, rigid, subcylindrical, often with a row of widely separated and exceptionally large spines, which usually



take the place of a cell aperture. Though varying from 0.6 to 1.2 mm., the average width of the branches is between 0.8 and 0.9 mm. Surface minutely granulose. Dissepiments slender, rounded, depressed. Fenestrules oblong subquadrate to elongate-oval, of variable width, averaging 2.4 by 0.8 mm. [not so long in the present examples], with 3 to 3.5 in 1 cm. [4 to 6]. Zoëcia in from 4 to 8 alternating ranges, normally in 5 or 6. Apertures 14 or 15 in 5 mm., subcircular, without peristome, appearing larger in worn examples than in perfect ones, widely separated longitudinally, and arranged in more or less regular intersecting diagonal series. Reverse of branches and dissepiments convex and finely striated.

"This species, although closely related to *P. halliana* Prout, can not be confounded with it. The fenestrules are so much longer, the branches stronger, more rigid and cylindrical, that a glance suffices to distinguish them. *P. simulatrix* resembles it more in its general aspect, but differs widely in important characters." (Ulrich, Geol. Surv. Ill., vol. VIII, pp. 588, 589.)

Bedford, Indiana, rare.

Indiana University collection.

#### POLYPORA SPININODATA Ulrich.

Plate XXXIX, figs. 2, 3.

Zoarium a foliar expansion. Branches stout, broadly rounded on the obverse, 0.4 to 0.6 mm. in diameter 14 to 15 to the cm. Fenestrules oval 0.35 by 0.65 mm.; 11 to the cm. on the average. Zoëcia large, with prominent peristomes, arranged in 3 or 4 alternating rows; 0.1 to 0.15 mm. in diameter. Reverse rounded and with large hollow spines at intervals. The only specimen in my collection is poorly preserved, but has the general appearance and measurements of this species.

Bedford, Indiana, very rare.

Indiana University collection.

#### PINNATOPORA SP?

Plate XXXIV, figs. 3-3a.

Two specimens of what seem to be fragments of the fronds of *Pinnatopora* have been found in the Bedford material. These are not of a nature to warrant more accurate identification.

Bedford, Indiana, very rare.

Indiana University collection.

## Genus DICHOTRYPA Ulrich.

Geol. Surv. Ill., VIII, p. 386.

"Zoaria consisting of large, thin, bifoliate expansions. The surface with solid maculæ. Zoecial structure in conformity with that given for the family [Cystodictyonidæ]." (Ulrich, *loc. cit.*)

## DICHOTRYPA FLABELLUM (Rominger).

Plate XXXIV, fig. 4.

Proc. Acad. Nat. Sci., Phila., 1866, p. 122.

"Zoarium having a strong, expanded base, roughly marked on the lower side with a concentrically wrinkled epitheca. On the upper side the base gradually contracts into a flattened or sub-cylindrical stem, which soon expands again into a bifoliate, fan-shaped frond, from 1.5 to 4.0 mm. in thickness, and several cm. in width and height. The base, stem, and lower portion of large examples is covered with a faintly striated dermatic crust. Above this the surface presents solid substellate maculæ, 4 or 5 mm. apart, bordered by apertures very slightly larger than the rest. In the perfect state the apertures are oval, 0.12 to 0.15 mm. in length, with the lunarium on one side more or less elevated. In the ordinary state of preservation they appear much larger (about 0.2 mm.) and the interspaces correspondingly narrower. The apertures are regularly arranged in intersecting lines, sometimes with six, but more commonly with seven in three mm. Interspaces generally a little elevated, and when well preserved covered with fine flexuous striæ. These also occur on the surface of the maculæ." (Ulrich, Geol. Surv. Ill., VIII, p. 501.)

Spergen Hill, Bloomington, Stinesville, and Lanesville, Indiana, very abundant.

Indiana University collection.

## DICHOTRYPA SP?

Plate XXXV, fig. 6.

A single specimen from Stinesville, Indiana, has the following characters: Zoarium a thin bilaminar expansion. Zoecia smaller than in *D. flabellum*, 0.1 to 0.15 mm. in diameter, 10 to 11 in 5 mm., arranged in intersecting lines. The margins of the aper-

tures are scarcely elevated, except on the lunar side; those surrounding the maculae are larger than those in the interval between maculae (about 1.5 mm. in diameter). The maculae are elongate, perfectly smooth, bounded by seven or eight zoecia with their lunaria facing the macula, and 1.5 mm. apart.

This form may be referable to the common *D. flabellum*.

Stinesville, Indiana, very rare.

Indiana University collection.

Genus CYSTODICTYA Ulrich.

Jour. Cincinnati Soc. Nat. Hist., V, pp. 152, 170.

"Zoaria ramose, bifoliate, the branches acutely elliptical in cross section, with sub-parallel, sharp, non-poriferous, striated, granulose, or smooth margins. Zoecia apertures generally arranged in longitudinal series between ridges, sometimes in more pronounced oblique rows. Apertures sub-elliptical, partially closed in the fully matured condition, with a more or less developed lunarium, that is always situated upon the side nearest to the margin of a branch. Interspaces finely striated, granulose or smooth, and never with pits or cells, excepting when worn." (Ulrich, Geol. Surv. Ill., VIII, p. 385.)

CYSTODICTYA LINEATA Ulrich.

Plate XXXV, fig. 1.

Jour. Cincinnati Soc. Nat. Hist., VII, p. 37, pl. II, 4-4c.

Zoarium bifoliate thin, 4 to 5 mm. wide, consisting of strap-like bifurcating fronds with sharp edges. Zoecia in 8 to 10 parallel ranges separated by very low ridges, which appear much more prominent in weathered than in well preserved specimens; alternating in adjacent rows, about 11 zoecia in 0.5 cm. longitudinally, and 12 in 0.5 cm. diagonally. Where well preserved the sides of the zoecia nearest the margins of the branch is elevated, hood-like. Spaces between zoecia faintly and finely striated and granulose.

Spergen Hill, Bloomington, Lanesville and Paynters Hill, Indiana, common; Bedford, Indiana, rare.

Indiana University collection.

## CYSTODICTYA OCELLATA Ulrich.

Plate XXXV, fig. 2.

Two specimens from Bedford, Indiana, have the appearance shown in pl. IX, fig. 2. There are practically no ridges between the rows of zoëcia, and the whole surface between zoëcia is uniformly covered with fine granules and fine sinuous striae. These are probably only exceptionally well preserved examples of *C. ocellata*.

Genus WORTHENOPORA Ulrich.

Geol. Surv. Ill., VIII, p. 403.

"Zoaria bifoliate, branching or palmate. Zoëcia very regularly arranged, subtubular, or rather, elongate rhomboidal, with the aperture semi-elliptical. On the surface the line of junction between the cells is marked by an elevated ridge. The truncated posterior margin of the aperture is raised into a less strong transverse bar. The elongate triangular depressed front appears perfectly plain." (Ulrich *loc. cit.*)

## WORTHENOPORA SPINOSA Ulrich.

Plate XXXV, fig. 3.

Geol. Surv. Ill., VIII, p. 669, pl. 68, figs. 1-1g.

"Zoarium a bilaminar elongate frond, 3 or 4 mm. wide, 0.5 to 0.8 mm. in thickness, branching dichotomously or otherwise at long intervals. Acutely elliptical in cross section. Margins subparallel, armed with a series of slender spines from 0.3 to 0.5 mm. long, pointing obliquely upward and outward. There are on each side about 16 in 3 mm. Zoëcia enclosed by an elevated sub-angular ridge, common to adjoining zoëcia. The space enclosed is elongate, somewhat rhombic in shape, drawn out long wedge-shaped posteriorly, and more rounded anteriorly; the whole usually 0.6 mm. long and 0.12 mm. wide. Aperture semi-elliptical, truncated posteriorly, 0.18 mm. long, and 0.1 mm. wide, occupying the anterior third of the space enclosed by the ridges, which form its margin except at the posterior side, where a thinner and less elevated line separates the aperture from the remainder of the enclosure. The latter forms an irregular subtriangular depressed space, with the bottom smooth and slightly

concave. When perfect five small tubercles, one on the posterior and two on each of the lateral margins, project into the aperture. Apertures arranged in regular, acutely intersecting, diagonal series, 9 in 3 mm., and in less regular transverse rows, between 8 and 9 in 2 mm. The marginal rows of zoecia are usually a little larger than the central ones." (Ulrich, *loc. cit.*)

My specimens do not show the marginal spines, and differ slightly in the measurements, but are evidently referable to this species.

Bedford and Bloomington, Indiana, rare.

Indiana University collection.

Normal range Keokuk.

#### WORTHENOPORA SPATULATA (Prout).

Plate XXXV, fig. 4.

Trans. St. Louis Acad. Sci., I, p. 446, pl. 17, figs. 2-2c.

"This species differs from *W. spinosa* mainly in the form of the zoarium, which is always more explanate, being usually of flabellate form. The margins are sharp and striate, and without spines. On one fragment many of the triangular suboval spaces are divided in half by a thin transverse ridge." (Ulrich, *Geol. Surv. Ill.*, VIII, p. 670.)

Bedford, Indiana, very rare.

Indiana University collection.

Normal range Warsaw.

#### Genus RHOMBOPORA Meek.

Paleontology of Eastern Nebraska, p. 141.

"Zoaria slender, ramose, solid. Zoecia with the vestibular or outer portion thick-walled. Apertures arranged regularly in diagonally intersecting or longitudinal lines. Strong acanthopores often present at the angles of junction and more numerous, smaller spines generally occupy the summit of the ridge-like interspaces between the sub-elliptical apertures. Diaphragms sometimes present in the axial region." (Ulrich, *Geol. Surv. Ill.*, VIII, p. 402.)

## RHOMBOPORA BEDFORDENSIS n. sp.

Plate XXXV, fig. 5.

Zoarium consisting of branching cylindrical solid stems arising from an expanded poriferous base. Diameter of branches 1.25 to 1.75 mm., and fronds attaining a length of several cm. Zoecia elliptical, about 0.075 mm. wide by 0.15 mm. long, arranged in regular diagonal intersecting rows about 4 to 5 in 1 mm., and about 3 in 1 mm. when measured along the longitudinal rows. The area about the mouth of the zoecia is somewhat depressed. Opposite the lower end of each zoecium is a prominent node, situated about one-third to one-fourth of the distance from this zoecium to the next zoecium below—i. e., toward the base of the branch. Besides these nodes there are on the older portions of the zoarium very obscure granules.

Bedford, Indiana, rather rare; Bloomington, Stinesville and Harrodsburg, abundant.

Indiana University collection.

## Genus FISTULIPORA McCoy.

Ann. Mag. Nat. Hist., Ser. 2, III, p. 131.

"Zoaria massive, lamellate, parasitic or free, with a wrinkled epitheca below; less commonly sub-ramose, the branches solid or hollow. Zoecia subradially arranged about the surface maculae, with ovoid, sub-triangular or pyriform apertures, the variations being due to the degree in which the lunarium is developed; internally with thin walls and a small number of complete horizontal diaphragms. Interspaces smooth or granular, internally occupied by one or more series of vesicular cells." (Ulrich, Geol. Surv. Ill., VIII, p. 382.)

## FISTULIPORA SPERGENENSIS Rominger.

Plate XXXVI, figs. 5 and 6.

Proc. Phila. Acad. Sci., p. 122.

"Undulated convexo-concave laminae, or strumose utracles and cyst, with an epitheca on the inner or inferior side. Tubules one-third of a millimeter wide, distant less than their own diameter. Orifices circular, surrounded by an elevated rim, which projects

more on the outer side. Many specimens have no elevated tube margins, and exhibit interstitial spaces with open cells; but this is only owing to an imperfect state of preservation, or the effect of detrition. Surface raised in obtuse unequal monticules, with cellulose maculæ in the center." (Rominger, *loc. cit.*)

Spergen Hill, Paynter's Hill and Lanesville, Indiana, very abundant; Bedford, Indiana, common.

Indiana University collection.

FISTULIPORA SPERGENENSIS var. MINOR n. var.

Plate XXXVI, fig. 4.

This form, of which one specimen has been seen, is associated with *F. Spergenensis* in the Spergen Hill material. It has more zoëcia to the cm. and very prominent erect hoods to the zoëcia. The specimen represents a young colony, and its peculiar characters may be due to immaturity.

Spergen Hill, Indiana, very rare.

Indiana University collection.

Genus GLYPTOPORA Ulrich.

Jour. Cincinnati Soc. Nat. Hist., vol. VII, p. 39.

"Zoaria forming thin, leaf-like expansions, composed of two subequal layers of cells, adhering to each other back to back. Both surfaces celluliferous, with an elevated, sharp midrib, or ridge, which may simply divide dichotomously at varying intervals, or inosculate more or less frequently, so as to leave irregular, cup-shaped depressions. The sharp margin of this ridge is non-poriferous, and may be either straight or serrated. Distributed with some regularity over the depressed portions of the two surfaces are sharply defined, more or less elongated, depressed maculæ or furrows, which may bifurcate once or twice. The remaining portions of the surface are uniformly occupied by the zoecial apertures, which, as usual, are provided with a small crescentic lip. Inter-zoecial spaces occupied by vesicular cells, which are filled and quite obliterated, in the 'matured' regions, by a secondary deposit." (Ulrich, *loc. cit.*)

## GLYPTOPORA MICHELINIA (Prout).

Plate XXXVI, fig. 1.

Trans. St. Louis Acad. Sci., I, p. 573.

"Zoarium encrusting or free, with a wrinkled epitheca on the lower side. Upper surface divided into, larger or smaller, deep, polygonal, cup-shaped cavities, enclosed by prominently elevated, sharp ridges, the summits of which, when in a good state of preservation, are serrated. The cups vary greatly in size, but are approximately equal on each example. The average width in the two largest specimens seen is about 12 mm., while in others it is only about 9 mm. At the bottom of the cups there is a more or less elongated depressed solid macula. Similar narrow maculae extend up the sides of the ridge at intervals apart of 2 mm., more or less. These maculae usually occupy corresponding positions on each side of the ridges, and being depressed, terminate before reaching their summits. The serrated character of the comb of the ridge is due to this circumstance. The spaces between the maculae is [are] uniformly occupied by the zoecia apertures. These are sub-circular, about 0.16 mm. in diameter and 9 in 3 mm., separated by interspaces equal in width to their diameter." (Ulrich, Geol. Surv. Ill., VIII, p. 515.)

Bedford, Indiana, very rare.

Indiana University collection.

Normal range Warsaw.

## Genus STENOPORA Lonsdale.

Darwin's "Volcanic Islands," Appendix, p. 161.

"Zoarium ramose, sublobate, massive, laminar or parasitic. Surface even or montiferous. In the mature region the zoecial tube walls are periodically thickened so as to appear moniliform in vertical sections. Comparatively large acanthopores are developed at the angles of the cells. Diaphragms straight, more or less numerous, with a large central perforation; a few irregular mesopores occasionally present." (Ulrich, Geol. Surv. Ill., VIII, p. 375.)



## STENOPORA SP?

Plate XXXVI, fig. 2.

Zoarium a thin crust-like expansion with a wrinkled epitheca on the reverse. Zoëcia very short, arising abruptly from the epitheca, rounded or irregularly polygonal, 0.2 mm. in diameter, 17 in 0.5 cm. Between the zoëcia there are occasional mesopores, especially at the interzoëcial angles. Interzoëcial walls thin, nodose when perfect (probably due to the acanthopores). An occasional perforated diaphragm may be seen in the apertures of the zoëcia. The internal characters of this species are not very fully known, on account of the lack of material. The zoëcial walls are periodically thickened, and acanthopores are small and numerous, which characters are, together with the perforated diaphragms, sufficient to place the form in the genus *Stenopora*.

Bedford, Indiana, very rare.

Indiana University collection.

## STENOPORA RUDIS Ulr.

Plate XXXVI, fig. 3.

Zoarium a circular, disc-like body, 10 mm. in diameter, with a concentrically wrinkled epitheca, with faint radial striations. Zoëcia usually pentagonal to square, but sometimes rounded, 0.25 to 0.3 mm. in diameter, about 14 to the half cm.; when well preserved a centrally perforated diaphragm may be seen in the zoëcia, depressed somewhat below its mouth. The ridges between the zoëcia are about 0.1 mm. thick and without nodes or spines except an occasional node at the angles. The material available has not made it possible to elucidate satisfactorily the internal structure. In tangential sections the walls appear rather thin, with a dark median lamina, and with an occasional obscure acanthopore at the angles. According to Mr. Bassler, this is a young specimen of *S. rudis*.

Bedford, Indiana, very rare.

Indiana University collection.

In Kindle's list of the fossils of Indiana (22d Ann. Rept. Indiana Geol. and Nat. Hist.), the following species of Bryozoa not described in the present paper are listed from the "Warsaw and St.

Louis" limestones, namely: *Archimedes laxus* (Hall), *A. Meekanus* (Hall), *A. Owenanus* (Hall), *A. reversa* (Hall), *A. wortheni* (Hall), and *A. Swallowanus* (Hall); all these are from beds higher than the Salem limestone; *Coscinium asterium* Prout, (*Fistulipora asteria*), *Coscinium elegans* Prout (*Glyptopora elegans*), *Coscinium escharensense* Prout (not recognizable), *Coscinium escharoides* Prout (not recognizable), *Coscinium Keyserlingi* Prout (*Glyptopora Keyserlingi*), *Coscinium tuberculatum* Prout (*Fistulipora? tuberculata*) *Coscinium Wortheni* Prout (not recognizable); (I have not seen specimens of any of these species in the material at my disposal); *Cyclopora discoidea* Prout (*Proutella discoidea*), (not seen); *Hemitrypa plumosa* (Prout) (this probably occurs at Spergen Hill and Lanesville); *Paleschara tuberculata* Prout (*Stenopora tuberculata*) (probably occurs in the Salem limestone; several specimens in the university collection may belong to this species); *Polypora Halliana* Prout (not seen); *Prismopora* [?] *serrata* (Meek) (occurs in higher formations); *Synocladia biserialis* Swallow (*Septopora biserialis*) (occurs in the Coal Measures).

## BRACHIOPODA.

BY J. W. BEEDE.

### ORTHOTHETES MINUTUS Cumings.

Plate XVIII, figs. 1-16; Plate XX, fig. 7.

*Orthothetes minutus* Cumings, Amer. Geol. Mch., 1901, p. 147, pl. 15.

"Shell semi-ovate to subquadrate in old individuals; hinge-line usually less than the greatest width of the shell, especially in young individuals; cardinal extremities forming an obtuse, or sometimes a right angle with the lateral margins. Surface finely plicated; plications increasing toward the margins by interstitial implantation. Crests of the plications crenulated by numerous equally spaced fine concentric lines.

"Ventral valve concave, with a pronounced tendency to irregular growth about the beak. In mature individuals the beak becomes strongly retrorse and greatly elevated, equaling in height one-half the length of the shell. Area well defined, flat, showing in well preserved specimens a low ridge on each side of the prominent deltidium and parallel with its margins. The younger specimens sometimes show a perforation of the apex of the deltidium.

"Dorsal valve regularly convex, greatest elevation about one-third of the way from the beak to the front margin, though there is considerable variation in this respect in individuals of different age. Usually some flattening at the cardinal extremities. Area very narrow or scarcely at all conspicuous.

"Interior of ventral valve showing rather prominent teeth, which diverge widely. Cardinal process in the dorsal valve elevated, projecting somewhat beyond the hinge-line; notch shallow, the grooves on the posterior faces of the apophyses very faint.

"Ratio of breadth to length of an average adult individual about as eleven to eight.

"Observation.—This form can not be referred to the *O. (Terebratulites) umbraculum* of Schlotheim,\* from which it differs in

\*Schlotheim, Petrefk. I, 256, II, 67; Schnurr, Brachiop. Der Eifel, 216. t. 38, fig. 2; t. 44, fig. 4; Bronn Lethæa, Geog. I, 361.

the less length of the hinge-line, fewer plications, greater proportionate elevation of the ventral beak, which in the present species becomes strongly retrorse, and the subquadrate rather than semi-circular outline of the shell. The figures of Schlotheim's species also show a strongly quadrilobate cardinal process, while in the present species the notch is very shallow and the grooves are very faint. The species to some extent resemble *O. lens*, from which it differs in the form of the cardinal process and the greater proportionate length of the latter species.

"Development.—In the search for specimens of this rather rare species (about fifty specimens were found among several thousand of the commoner Spergen Hill forms) a number of very young stages were obtained. While even the adult individuals share in the general stunting so characteristic of the entire Spergen Hill fauna no complete specimen in the writer's collection having a length of more than 5 mm., nevertheless these larger individuals present the usual features of maturity.

"The smallest individual observed has a length of 0.6 mm. and a breadth of 0.9 mm. In this specimen the ventral valve is roughly conical in shape, though slightly more convex toward the beak, which projects conspicuously beyond the hinge-line and is very prominent. The surface shows eighteen plications at the margin, as against forty in the largest individual observed, while the posterior third of the shell is without ornamentation except a few obscure concentric markings. The area is high and the large deltidium less sharply marked off from it than in the older individuals. The breadth at the hinge is conspicuously less than farther forward.

"The dorsal valve has its greatest convexity at the center and is also smooth for a considerable distance from the beak. It shows no sign of an area.

"Individuals of the length of 2 mm. have the area perpendicular to the plane of separation of the valves, and the ventral valve showing a slight convexity toward the front. The number of plications has increased from 18 to 22 or 23, and the region of greatest convexity in the dorsal valve has approached somewhat the beak. The youngest individual shows a marked conformity to the generalized type of brachiopod, as was found by Beecher and

Clark to be the case in the species of the Waldron fauna."\* (Cumings.)

Localities.—Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville, Lanesville.

Specimens of this species occur having a width of about two inches. The beak of the pedicle valve is variable, and usually high in old individuals, and the valve is usually heavily wrinkled. In specimens of a centimeter or thereabouts in diameter the brachial valve is very convex in longitudinal outline.

#### PRODUCTUS BISERIATUS Hall.

Plate XXII, figs. 8-12; Plate XIX, fig. 6.

*Productus biseriatus* Hall, Trans. Alb. Inst., IV, p. 12, 1858.

"Shell longitudinally ovate; pedicle valve extremely gibbous, without sinus, arcuate, marked by five or six elevated distant concentric undulations which are ornamented upon their dorsal margins by a single row of elongate pustules or nodes; and on their middle and basal margins by numerous smaller granulations; beak attenuate and extremely arcuate; brachial valve semi-oval, flattened near the base, having the greatest concavity near the beak, which is obtuse; surface of the brachial valve marked by eight or nine closely arranged, concentric bands, which are marked by granulations, as in the pedicle valve; hinge-line scarcely so wide as the greatest width of the shell; extremities rounded." (Hall, slightly emended.)

Localities.—Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville.

"The specimens of this species present all the features of *P. vittatus*, Hall \* \* \* but dwarfed. The smaller individuals are so closely similar to the form known as *P. alternatus*, Norwood and Pratten, 1854, which is perhaps not distinct from *P. vittatus*. There are great variations among the specimens usually included under the name *P. vittatus* and the passage from the one to the other extreme, as marked by the three forms, is so gradual that it is doubtful if they should not all be included under the one name of *P. alternatus*." (Whitfield.)

I am unable to find any differences of moment between this species and *P. alternatus*, but without the material of the latter species at hand it would be presumptuous for me to say that they are identical. Well preserved material shows the "granulations" of Hall to be the bases of very long, slender spines, which are sometimes so thick and long as to hide the shell.

#### PRODUCTUS INDIANENSIS Hall.

Plate XXII, figs. 6-7; Plate XIX, figs. 7-7a.

*Productus indianensis* Hall, Trans. Alb. Inst., IV, p. 13, 1858.

"Shell sub-ovate, gibbous, inflated; pedicle valve without sinus, gradually contracted towards the beak, which is large and strongly arcuate, obtuse at the extremity and very gibbous below; surface pustulose or aculeate, marked by extremely fine, concentric striae, and a few irregular undulations; pustules or bases of spines irregularly distributed over the surface of the shell, with a linear series down each side below the hinge extremity; hinge-line apparently less than the width of the shell." (Hall, slightly emended.)

Localities.—Lanesville, Spergen Hill, Bedford, Harrodsburg, Bloomington, Paynters Hill.

"It is extremely difficult to point out the differences between this and the preceding species. The specimens are a little more ventricose on the umbo of the ventral valve than those of *P. biseriatus*, while the entire shell is more rotund. The surface marking, what little there is left on the specimens, is of the same character precisely as on that one, so the specific distinction will have to rest entirely on the external form. I have seen interiors of dorsal valves of this form which have a thickened border very distinctly marked, and which have not shown any evidence of concentric undulations. But there are none in the collection that can be figured." (Whitfield.)

If the material in hand is what Hall referred to this species, as it appears to be, it is certainly distinct from *P. biseriatus*. As Whitfield points out, the entire shell is more rotund, and corresponding with this the brachial valve is very much more concave than that of *P. biseriatus*. Whitfield's figures hardly bear out his statements concerning the surface markings of the two. The first two millimeters of the shell of *P. biseriatus* from the point of

the beak are identical in appearance and markings with the entire shell (so far as observed) of *P. indianensis*, viz., having rows of single spines of uniform size *without having the shell divided into sharply marked zones*. After passing two or two and a half millimeters from the tip of the beak the concentric zoned area sets in abruptly, and with it the double series of large and small spines. The small spines have not been observed on specimens of *P. indianensis*, nor do the zonal marks appear on either valve. These characters have been observed on specimens a centimeter in length, the largest seen of this species. Spines have been observed on the brachial valve of this species similar to those of the other valve. On the *P. biseriatus* they have been seen nearly as long as the specimen itself.

The distinction in the general appearance of well preserved specimens is sufficient enough for students to differentiate them in the field. One student compared *P. indianensis* with its spines to a "wild cucumber," a remark that is very suggestive when the spines of the fossil are preserved.

#### PRODUCTUS BURLINGTONENSIS Hall, Var.

Plate XVII A, figs. 1-1c, 4-4a; Plate XX, figs. 1-1c.

*Productus flemmingi* var. *burlingtonensis* Hall, Geol. Rep. Iowa, I, Pt. II, p. 598, pl. XII, ff. 3a-g, 1858.

"Shell of medium size or larger, longer than wide, sometimes the length and breadth equal: hinge-line less than the width of the shell below; cardinal extremities auriculate, ventral valve extremely ventricose, recurved, bringing the beak opposite or below the center of the valve, and nearer the base than the width of the hinge-line; marked by a central longitudinal sinus, which is more or less strongly defined, and reaches from near the beak to the base. Dorsal valve moderately concave, and sometimes nearly flat in the upper part and abruptly curved or geniculate in the middle, the lower portion being rectangular to the upper; sometimes a slight elevation along the center of the lower part.

"Surface of the ventral valve marked by regular rounded radiating ribs, which bifurcate a few times, the bifurcations occurring almost wholly above the center of the shell; transversely marked

by fine concentric striae, and some strong wrinkles on the upper part of the valve, and a few inconspicuous undulations upon the middle of the shell. Scattered, rounded, tubular spines occur on the middle and lower part of the shell at the coalescing of the ribs and rarely a row near the base, with smaller ones sometimes at the base of the ears and toward the hinge-line.

"Interior of the dorsal valve showing a bifurcate cardinal process, each branch of which appears to be slightly bilobed at the extremity, proceeding from a thickened interior cardinal margin and connected with a short median ridge; the reniform vascular areas widely separated." (Hall.)

Localities.—Spergen Hill.

Our specimens from the base of the Salem limestone at Spergen Hill are so similar to those of this species as figured by Hall and Clarke that there seems no doubt of their close relationship to this species, though this species has not been recorded from so recent a horizon before. They are intermediate in form between *P. burlingtonensis* and *P. marginicinctus* and *P. wortheni*, which are probably identical. The species here described may be a variety of *P. burlingtonensis*. They are abundant in places in the Harrodsburg limestone below.

#### PRODUCTUS GALLATINENSIS Girty.

Plate XVIIIA, figs. 2-2a, 3-3e.

*Productus gallatinensis* Girty, U. S. Geol. Surv. Mon. XXXII, pt. II, p. 533, Pl. LXVIII, ff. 7a-c, 11-11d, 1899.

Shell small, very arcuate, plump. Beak prominent, strongly recurved and produced. Ears not well shown, but somewhat convex and extending out as far as the shell in front; wrinkled and somewhat spinous; separated rather distinctly from the body of the shell. Pedicle valve large, very gibbous, without distinct sinus and rapidly inflating from the beak; in old individuals the margin is produced well below the level of the hinge-line. The entire valve has a very plump, ventricose appearance. The visceral portion, particularly the posterior part of it, is pretty regularly marked by concentric wrinkles which disappear on the upper anterior portions of the shell. The valve is also marked by rather fine radiating costae, about 56 to the inch. Like most of



the striated species of the genus the ribs bifurcate on the visceral region and coalesce to a greater or less degree on the front. The anterior surface has a few coarse spines. The brachial valve is quite concave near the beak, flattening, but still remaining concave, to the margin of the visceral region, where it bends abruptly downward. Surface marked as in the other valve except, perhaps, for the spines.

The relative dimensions of this species correspond with those of *P. gallatinensis* Girty, and, judging by his figures, the surface marks are almost identical as is the appearance and curvature of the shell. They are of the same size and are probably specifically identical.

This shell is strikingly like *Productella arcuata* Hall, but is a true *Productus*.

The difference between *P. gallatinensis* as figured by Girty and *P. parvus* M. and W., is rather slight to be considered of specific value in this genus. I should not be surprised if, after all the intermediate forms have been worked out, and the rocks thoroughly collected from, *P. gallatinensis* and *P. parviformis* Girty, were classed under *P. parvus* M. and W.

Localities.—Spergen Hill.

At Spergen Hill this species is characteristic of the base of the stratum.

#### RHIPIDOMELLA DUBIA Hall.

Plate XXII, figs. 1-4.

*Orthis dubia* Hall, Trans. Alb. Inst., IV, p. 12, 1856.

"Shell circular, or oval-ovate; valves nearly equally convex, the brachial valve somewhat more rotund; pedicle valve flattened in the middle, with broad depression extending thence to the front of the shell, giving it a sinuous outline; beak of the pedicle valve extended beyond the opposite valve, slightly incurved, with a triangular foramen; area very small, and (with the foramen of the pedicle valve) nearly covered by the beak of the brachial valve, which curves toward the opposite valve, bringing the two almost in contact at their margins. Surface marked by fine, rounded, closely arranged striae, which increase by bifurcation and implantation; the striae down the mesial depression are distinctly tubu-

lar, with minute, pore-like openings at intervals, directed downwards. These are probably the bases of minute tubular spines, which were closely imbricated. Minute pore-like openings are sometimes seen on other parts of the shell, but never so conspicuous as in the pedicle sinus." (Hall, slightly emended.)

Localities.—Lanesville, Paynters Hill, Spergen Hill, Harrodsburg, Bloomington.

"This species is more nearly allied to *Orthis theimeii* White, from the sandstones below the Burlington limestones at Burlington, Iowa, than to any other one. It differs, however, in the more pointed beak and rapidly sloping cardinal margins, in its narrower form and less regularly convex dorsal valve. The species is also remarkable for the thickening of the valves in older specimens, especially of the ventral valve. Subsequent collections have shown it to attain a considerably greater size than that given under the original description; specimens from Paynters Hill measure five-eighths of an inch in length. In such examples the striae become very much elevated and exsert, and the shell remarkably thickened."

#### CAMAROPHORIA SUBCUNEATA Hall.

Plate XXII, figs. 47-49.

*Rhynchonella subcuneata* Hall, Trans. Alb. Inst., IV, p. 11, 1856.

"Triangular, subcuneate; front rounded, meeting the lateral slopes at an obtuse angle; sides sloping to the beak and meeting at an angle of 60 or 65 degrees; valves nearly equally convex, pedicle valve most convex towards the beak; beak of pedicle valve very acute, scarcely incurved, and perforate by a triangular foramen; beak of brachial valve acute, closely incurved below the triangular foramen. Surface marked by about twelve to fourteen (and rarely sixteen) strong, simple, angular plications, which are somewhat obsolete near the beak; scarcely any indication of a sinus; plications crossed by fine concentric striae, and in old shells at irregular distances, by stronger imbricating folds or wrinkles parallel with the lines of growth; sides of both valves beneath the beak free from plications, and forming a very distinct elongate-oval space. Length, .16 to .41; width, .15 to .39 of an inch." (Hall, slightly emended.)

Localities.—Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville, Paynters Hill, Lanesville.

CAMAROPHORIA WORTHENI Hall.

Plate XXII, figs. 35-39.

*Rhynchonella wortheni* Hall, Trans. Alb. Inst., IV, p. 11, 1858.

"Shell small, longitudinally sub-trigonal, very abruptly tapering to the apex; brachial valve very convex or gibbous towards the front; pedicle valve nearly flat and broadly sinuate in front, with a single broad, flattened plication, commencing near the margin, and filling a deep sinus in the opposite valve, corresponding to two short, rounded plications on the front of the brachial valve; edges of the shell on each side of the mesial sinus sharply undulated, with distinct marginal folds; beak of pedicle valve pointed, straight, with triangular foramen. Surface marked by fine concentric striae, and some faint remains of finer radiating striae. Length .22, width .24 of an inch." (Hall, slightly emended.)

Locality.—Alton, Ill.

PUGNAX GROSVENORI Hall.

Plate XXII, figs. 31-34.

*Rhynchonella grosvenori* Hall, Trans. Alb. Inst., IV, p. 10, 1858.

"Shell globose or subtriangular, rotund or depressed; brachial valve more convex than the other, greatest convexity of the two valves near the front, sloping abruptly towards the beak, where the two sides meet at nearly a right angle; beak rather small, neatly defined, nearly straight or slightly incurved, with a linear or a subtriangular foramen; beak of opposite valve round and obtuse, closely incurved. Surface marked by from 14 to 18 distinct, rounded, simple plications, which often become obsolete towards the beaks; four or five of the folds depressed, forming a sinus on the larger valve, with a corresponding elevation of five or six plications on the opposite valve. Length .14 to .22, width .13 to .23 of an inch." (Hall, slightly emended.)

Localities.—Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Lanesville, Stinesville, Ellettsville.

"The nearly globular or depressed globular form will readily distinguish this from any lower Carboniferous species of the genus." (Whitfield.)

## PUGNAX MUTATA Hall.

Plate XXII, figs. 43-45.

*Rhynchonella mutata* Hall, Trans. Alb. Inst., IV, p. 10, 1858.

"Shell subtrigonal, more or less gibbous, front broadly rounded or nearly straight, abruptly tapering to the apex, the two sides meeting at an angle of nearly 90 degrees; brachial valve much more convex than the opposite one, which is often depressed, shell most convex near the anterior margin; beak of pedicle valve nearly straight or but slightly incurved; foramen triangular; beak of the opposite valve obtusely angular and closely incurved against the pedicle valve. Surface marked by from 12 to 16 strong, sub-angular plications, about four or five of which are depressed in the sinus of the pedicle valve; sinus not deeply impressed on the margin of the shell; concentric striae rarely visible. Length .15 to .30, width .14 to .32 of an inch." (Hall, slightly emended.)

Locality.—Alton, Ill., Warsaw, Ill.

This species may be distinguished from *Camarophoria subcuneata*, which it resembles, by its shorter and broader form.

## PUGNAX? QUADRIROSTRIS N. SP.

Plate XIX, figs. 4-4c.

Shell very small, quadrangular in outline; beaks not prominent; shell widest near the center. Pedicle valve crescent-shaped, more convex near the beak; deeply sinuate most of its length, the lateral edges in the central portion are elevated into angulated points. The valve sometimes has an impressed line along the sinus. The anterior margin is prolonged into a very pronounced linguatiform extension. Pedicle opening nearly closed by the opposite valve; form of the opening unknown. The brachial valve is smaller than the other, the beak is nearly as prominent. The valve is convex at the beak and concave the remainder of the distance to the front; transversely very convex in the central part between the lateral angles. The surface is ornamented by about three or four very faint radiating costae on each side of the valves, and by faint growth marks.

Localities.—Harrodsburg, Stinesville.

There are two specimens from each place. Those from the Big Creek quarry (Stinesville) are more robust than the Harrods-

burg specimens, but the latter are better preserved and show the surface ornamentation.

When these specimens are held in the hand the appearance of the anterior and posterior ends and the two lateral angles is so similar that either of the four might be taken for the beaks, at a cursory glance, and the shell is so shaped as to carry out the resemblance.

Nothing is known of the internal characters of these shells, and the generic reference is based wholly on surface expression. Their actual relationships can only be worked out when material comes to hand showing the critical characters. This species slightly resembles *Terrebratula meyendorffii* Murch., de Vern. and Keyserling, but differs in having by far the greater part of the brachial valve of concave outline instead of sharply convex. The resemblance is probably superficial. Another species which might be mentioned in this connection is *Terebratula acuminata* Martin, but this resemblance is remote.

#### RHYNCHONELLA MACRA Hall.

Plate XXII, figs. 40-42.

*Rhynchonella macra* Hall, Trans. Alb. Inst., IV, p. 11, 1858.

"Shell triangular, flattened; apex acute; valves nearly equal; dorsal valve a little more convex toward the beak, which is quite straight, extended beyond the lesser valve, and with a sub-triangular foramen, which is slightly rounded above. Surface marked by from 18 to 24 small, rounded plications, which are about equal to the spaces between. Length .15 to .24, width .14 to .29 of an inch." (Hall.)

Locality.—Alton, Ill.

"The peculiar flat form of this species will readily distinguish it from the other associated species, except from the young shells of *P. mutata*. From such specimens it will be almost impossible to separate them without leaving some question as to their identity." (Whitfield.)

## RHYNCHONELLA RICINULA Hall.

Plate XXII, fig. 46.

*Rhynchonella ricinula* Hall, Trans. Alb. Inst., IV, p. 9, 1858.

"Shell very small, longitudinally ovate or sublenticular, neatly rounded in front; valves almost equally convex; beak of pedicle valve straight, comparatively much extended, perforate by a triangular foramen; surface marked by from 12 to 16 angular plications, which often terminate abruptly about one-third the distance from the base to the beak, sometimes becoming obsolete on the upper half of the shell. Length .11, width .10 of an inch." (Hall.)

Localities.—Spergen Hill, Harrodsburg.

"The minute size of this shell might readily be considered its chief specific feature, were it not that the young of other species are found in the same rock. Those of *R. macra* so nearly resemble it as to preclude any possibility of distinguishing between them, except by the adult aspect which shells of this species present. As no adult forms of *R. macra* have been found at Spergen Hill or Bloomington, however, they will give but little trouble. The very young shells of *C. subcuneata* and *P. grosvenori* are often mistaken for this one, and I can not see that there is any sure means of distinguishing between them." (Whitfield, slightly emended.)

## CENTRONELLA?? CRASSICARDINALIS Whitfield.

Plate XXII, figs. 50-52.

*Centronella crassicardinalis* Whitfield, Bull. Amer. Mus. Nat. Hist., I, p. 55, pl. VI, ff. 50-52, 1882.

"Shell of about medium size and nearly circular outline, the length of the ventral valve being slightly greater than the width; longitudinally it is strongly arcuate or curved from beak to base, but nearly flat transversely, except near the front, where it becomes slightly sinuate. Beak of the ventral valve projecting beyond the hinge fully one-fourth the length of the valve, with the cardinal slopes very large, broad and flattened, making the extreme posterior edge of the valve rather sharply angular. Foramen small and round; deltidial opening large and triangular; teeth strong. The interior of the valve seems to have been occupied largely by the muscular scars, while the cardinal edges of the valve have been

greatly thickened, so as to present a very unusual character. Dorsal valve unknown. Surface, as indicated by the ventral valve only, marked by concentric varices of growth." \* \* \* (Whitfield.)

Locality.—Spergen Hill.

There is very little doubt but that this shell is the same as the one described by Hall and Clarke as *Athyris densa* from this same locality and horizon. It is not referred here positively as no specimens occur in our collection of exactly the form of the type and I had no opportunity to study them. I have no doubt of their being synonymous, however. In this case the shell will be known by Hall and Clarke's specific name, as *A. crassicardinalis* is preoccupied.

**DIELASMA TURGIDUM Hall.**

Plate XXII, figs. 53-58; Plate XIX, figs. 5-5a.

*Terabratula turgida* Hall, Trans. Alb. Inst., IV, p. 6, 1858.

"Shell longitudinally ovate, often extremely gibbous, emarginate in front, pedicle valve most convex in the middle, having a sinus extending to the base of the shell; beak large, rounded and prominent, incurved and pointed, with an oval or subcircular foramen just above or in the extremity. Brachial valve most convex in the middle or near the front, with or without a short sinus, in which is sometimes a short and obscure fold. Surface marked by strong concentric lines of growth; and near the front, in some shells, are strong wrinkles or folds which distort the form of the shell. Length .16 to .32, width .13 to .27 of an inch." (Hall, slightly emended.)

Localities.—Lanesville, Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville; Warsaw and Alton, Ill.; Boonville, Mo.

"This is a very good miniature representative of *T. sacculus*, Sow., of the Carboniferous limestones of Europe, but although recognized at many localities in this country, it is never of such large size as is common with that species. It is very variable in its degree of ventricosity, sometimes increasing enormously in adult individuals, although they may be of small size. Some individuals have a thickness through the valves fully equal to the entire length of the shell." (Whitfield.)

## DIELASMA FORMOSUM Hall.

Plate XXII, figs. 59-64.

*Terebratula formosa* Hall, Trans. Alb. Inst., IV, p. 6, 1858.

"Shell longitudinally oval-ovate; dorsal valve more convex in the middle and upper part; beak extended upwards, prominent, incurved; valves compressed near the front, which is neatly rounded, the margin presenting a slight undulation; sometimes sinuate in front. Surface marked by fine concentric lines of growth, and sometimes by parallel stronger folds or wrinkles. Under the magnifier the shell presents a finely punctate structure. Length .14 to .44, width .10 to .31 of an inch." (Hall.)

Localities.—Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville, Lanesville.

"This is a beautiful and generally very symmetrical species, but it varies much in form and also in size. The typical specimens were scarcely half an inch long, but among more recent collections specimens measuring about one and one-half inches have been observed." (Whitfield.)

## DIELASMA GORBYI Miller.

Plate XX, fig. 5.

*Terebratula gorbyi* Miller, Adv. Sheets 17th Ann. Rep. Geol. Surv. Ind., p. 77, pl. XIII, ff. 3, 4, 1891. Same Rep., p. 687, pl. and fig. same, 1892.

"Shell variable in size, but growing very large; elongate-elliptical in a dorsal view; cuneate in front in a side view; valves unequally gibbous; rounded in front; sides subparallel. Shell structure beautifully punctate, under an ordinary magnifier, and the punctures may be seen with the unaided eye.

"Ventral valve more gibbous than the dorsal; arcuate from the beak to the front; greatest convexity in the middle part; beak very prominent, strongly incurved, inflated along the umbonal slopes; truncated by a very large foramen. No hinge area.

"Dorsal valve much shorter than the ventral, less gibbous, somewhat depressed, convex in the middle part; beak incurved beneath the beak of the ventral valve. No hinge area.

"This species may be distinguished by its large size, elongate-elliptical form and large foramen.



"Found by Prof. S. S. Gorby in the Keokuk Group, at Edwardsville, Indiana, and now in his collection and in the State Museum at Indianapolis. The specific name is in honor of the collector." (Miller.)

Locality. "Warsaw Group, Edwardsville, Indiana." The specimen figured was loaned by Mr. G. K. Greene.

A specimen purporting to be the type of this species, in the University of Chicago, is from, to all appearances, the Greensand of New Jersey. It will have to be admitted also that it looks suspiciously like the figure in the 17th Indiana report. The two species are sufficiently similar in appearance that it is difficult to say whether it is the shell described, or whether the mistake was complete all around. However, there can be no such mistake concerning the specimen here figured.

#### SPIRIFERINA NORWOODANA Hall.

Plate XXII, figs. 16-17.

*Spirifer norwoodana* Hall, Trans. Alb. Inst., IV, p. 7, 1858.

"Shell small, semi-elliptical, very gibbous, angles rounded; hinge line shorter than the greatest width of the shell. Pedicle valve very convex and strongly arching near the beak, which is curved over the area; plications about eight, the central ones very strong and the mesial depression distinctly continued to the beak. Brachial valve ranging from depressed convex to extremely convex, and marked by three strong plications on each side of the mesial fold, which has often a depressed line along the center towards the base, with scarcely a distinct fold in the sinus of the pedicle valve. Area small, high, not extending to the extremities of the hinge; foramen scarcely higher than wide; surface, in unworn specimens, marked by concentric, imbricating lamellae. Length .07 to .18, width .08 to .21 of an inch." (Hall, slightly emended.)

Localities.—Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville.

"The shells of this species bear the same relations to *Spiriferina spinosa*, N. and P., that those of the above species do to *S. leidevi*, except that these are rotund, in which feature they show more of an adult stage than do any of those of the other form. The shell of the best preserved specimen of this species preserves the

spinose surface, and under a strong glass faint indications of the punctate structure so distinctive of *S. spinosa* is discernible. As both *Spirifer leidevi* and *Spiriferina spinosa* occur of the normal form at three of these localities, it would be natural to suppose these dwarf specimens may bear some close relations to those species." (Whitfield.)

After careful examination of a good lot of material of normal size from Bloomington and Bedford in practically perfect state of preservation, I believe this is a valid species. The surface of *S. norwoodana* does not possess the large spines of *S. spinosa*. The pustules are all of equal size and rather highly elevated and contain the exterior openings of the punctae. In Norwood and Pratten's species from younger rocks a portion of these pustules are developed into larger spines.

There is no imperforate covering of the valves, as described by Girty for some western relatives of *S. spinosa*.

#### SPIRIFER SUBORBICULARIS Hall.

Plate XIX, figs. 3-3a; Plate XXI, fig. 4.

*Spirifer suborbicularis* Hall, Geol. Rep. Iowa, I, pt. II, p. 644, 1858.

"Shell suborbicular, length and width nearly equal, or somewhat wider than long; hinge-line much shorter than the width of the shell; cardinal extremities regularly curved. Dorsal valve convex, gibbous above the middle, with the mesial fold becoming defined below the beak, and somewhat prominent at the base. Ventral valve convex, gibbous above the middle, with elevated umbo and beak abruptly incurved over a narrow area, which in length is about equal to half the width of the shell; foramen with the dental lamellae projecting, and partially closed by a pseudo-deltidium."

"Surface marked by broad, flattened, scarcely defined plications, of which there are seven or eight on each side of the mesial fold and sinus, with two or three more faintly defined on these parts of the shell, and some appearance of a smaller plication in the center of the sinus.

"This species has usually been referred to *S. pinguis*; but it differs in being more orbicular, and having a proportionately more

extended hinge-line, as well as the extremely flattened plications, by which it may be distinguished from all other species which have fallen under my observation from the Carboniferous rocks." (Hall.)

The pedicle valve is characterized by fairly strong teeth, supporting high, long, thick dental lamellae, which extend nearly a third the distance to the front of the shell, or two-thirds the distance to the front end of the muscular scars. Area of scars sub-elliptical or paddle-shaped, the small ridges radiating, more or less, from the central line, which may be rough, but is not elevated into a septum. The relative length of the hinge varies very greatly in different individuals, being anywhere from scarcely one-third to a half the width of the shell.

Localities.—Lanesville, Bedford.

#### SPIRIFER SUBCARDIIFORMIS Hall.

Plate XXI, figs. 2-2b.

*Spirifer subcardiiformis* Hall, Geol. Rep. Iowa, I, pt. II, p. 660, 1858.

"Shell sub-elliptical in marginal outline, a little wider than long; hinge-line shorter than the greatest width of the shell. Dorsal valve a little less convex than the ventral, its beak somewhat prominent and projecting beyond the hinge-line; mesial fold rather broad in front, slightly elevated, marked by four plications, which all coalesce at the beak; a very slight elevation appears in the bottom of the groove which separates the two middle plications of the fold, and the two grooves which separate the fold from the lateral portions of the valve are broader than any of the others; from seven to nine simple, rounded plications mark the space on each side of the fold, the inner ones being strong and the outer ones becoming obsolete. Ventral valve having its beak prominent, incurved and projecting back further than that of the dorsal valve; mesial sinus broad, not deep, bearing three plications; from seven to ten plications on each side of the mesial sinus, which correspond in character with those on the other valve; the posterolateral portions of the valve rounded into the area, which is very short and its limits ill-defined; foramen moderately large, triangular, and nearly equilateral.

"Length from ventral beak to front 28 millimeters; greatest breadth 32 millimeters; greatest thickness, both valves together, 18 millimeters.

"This species was originally described from an imperfect example which was obtained from the Warsaw limestone near Alton, Ill. Among a collection of fossils obtained by Mr. William Gурley, from equivalent strata at Spergen Hill, Indiana, is a more perfect example, which has served as the basis for the description and illustrations herein given." (White.)

Localities.—Spergen Hill, Bedford.

So far as I have observed these fossils are confined to the base of the stratum, and are most abundant near the north end of the cut at Spergen Hill.

*SPIRIFER LATERALIS DELICATUS* Rowley, var.

Plate XX, figs. 3-3a.

*Spirifer lateralis* var. *delicatus* Rowley, Cont. Ind. Pal. I, p. 68, pl. XXIII, ff. 21-23, 1901.

"The several specimens of this shell differ from Hall's figures and descriptions of *Spirifer lateralis*. They are much smaller and have very much finer plications, sharper in outline. The differences are hardly more than of varietal significance, however."

"The figured specimens were collected from the Warsaw limestone at Lanesville, Indiana, and form a part of the collection of Mr. G. K. Greene." (Rowley.)

I have not seen these specimens.

*SPIRIFER BIFURCATUS* Hall.

Plate XXII, figs. 13-15.

*Spirifer bifurcatus* Hall, Trans. Alb. Inst., IV, p. 8, 1868.

"Shell semi-elliptical in general form; pedicle valve gibbous; brachial valve depressed convex; plications seven or eight, which appear to coalesce towards the cardinal margin; mesial fold with a defined depression in the center, reaching half way to the beak; surface longitudinally striated and concentrically marked by fine lines. Length .09, width .11 inch." (Hall, slightly emended.)

Localities.—Lanesville, Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville, Romona.

"The individuals of this species in the original collection are extremely minute, and bear evidence of immaturity. Among the later collections are a number of larger specimens and others of intermediate sizes, showing a tendency to greater development in the length of the hinge-line and angularity of the plications. The larger specimens present exactly the features of partially grown specimens of *Spirifera leideyi*, N. and P., from the Chester limestones; and from this direction in the development by increased growth leave no doubt of these being dwarfed individuals of that species. A comparison of the three figures given, taking into consideration that they are enlarged six, three and two diameters, respectively, will show this development of features." (Whitfield.)

This species differs from *S. leideyi* in never having but a single sharp rib in the sinus and two on the fold, while the typical specimens of that species have one large rib and two accessory ones in the sinus. Norwood and Pratten's species was described from the Chester beds. This would indicate that the addition of the accessory plications in the sinus took place at a later time than represented by the Salem limestone.

There are specimens from Lanesville preserved in chert (resembling the chert of the Mitchell limestone) that show the characters of *S. leideyi*. However, these were taken from residual clay and chert fragments from hillsides, and the horizon can not be depended on with absolute certainty, and any particular specimen may have come down from the rocks above. These remarks apply to much of the Lanesville material.

#### SPIRIFER HORIZONTALIS Rowley.

Plate XX, figs. 2-2a.

*Spirifer horizontalis* Rowley, Cont. Ind. Pal. I, p. 67, pl. XXIII, ff. 13-15, 36, 1901.

"Valves unequal in length, the pedicle being quite one-third longer than the brachial. The greatest convexity in either valve is nearer the anterior than the posterior part of the shell, and the greatest thickness at the middle of the pedicle valve.

"A slight depression traverses the mesial fold, making it appear to be a double plication. Ten simple plications on either side of the mesial fold.

"A very distinct elevation down the middle of the sinus. Ten plications on either side of the sinus.

"The shell is crossed with crowded lamellose lines of growth. Cardinal extremities pointed but not acute. Cardinal area the greatest width of the shell and forms a low, broad triangle, confined entirely to the pedicle valve.

"The horizontal position of the cardinal area where the shell rests on the middle of either valve, is the chief character of this little brachiopod. The character is constant, being shown by all the specimens before us, three double and two separate valves.

"The flattening of the pedicle valve immediately over the cardinal area is due to this character.

"This species was collected from the Warsaw limestone at Lanesville, Indiana, and now in the collection of Mr. G. K. Greene." (Rowley.)

I have seen no specimens of this species.

#### SPIRIFER SUBÆQUALIS Hall.

Plate XX, figs. 4-4b; Plate XXI, figs. 3-3b.

*Spirifer subæqualis* Hall, Geol. Rep. Iowa I, pt. II, p. 663, pl. XXIII, ff. 9a-c, 1858.

"Shell semi-elliptical, about twice as wide as long; valves almost entirely equal, the beak of the ventral valve being very slightly elevated above the opposite. Dorsal valve depressed convex; the mesial fold obtusely angular, scarcely defined at its margins: a narrow cardinal area, which is conspicuous in well preserved specimens. Ventral valve somewhat gibbous on the umbo: beak slightly incurved: mesial sinus not observable on the upper half of the shell, and becoming a broad depression with undefined margins below: area of moderate width extending to the cardinal extremities; foramen large, the width of the base greater than the length of the side.

"Entire surface, including the sinus and fold, marked by simple rounded plications, which bifurcate near the beak, and of which there are about 18 on each side, and about 8 on the mesial fold and 10 in the sinus; concentrically marked by undulating laminae of growth and finer striae." (Hall.)

Locality.—Lanesville.

The number of plications on the valves of Hall's figures, cited above, is in excess of the statement in the description. Our specimen agrees very well with the figures, but is a larger, longer-hinged specimen, with a correspondingly larger number of ribs. The hinge extremities are also more pointed.

RETICULARIA PSEUDOLINEATA Hall?

Plate XXI, fig. 5; Plate XX, figs. 6-6a.

*Spirifer pseudolineatus* Hall, Geol. Iowa, I, pt. II, p. 645, pl. XX, f. 4, 1858.

Hall's original description of this species is: "Shell transversely elliptical, length about three-fourths as great as the width, the sides symmetrically rounded: valves about equally gibbous. Dorsal valve with the beak a little elevated above the hinge-line and incurved, marked by rounded, undefined mesial fold which is often scarcely visible above the middle of the shell, and moderately conspicuous on the lower half: lateral portions of the valve regularly curving to the margin. Ventral valve more gibbous above the middle; mesial sinus shallow, rounded, becoming more defined below, and rarely extending to the beak, which is prominent, attenuated and incurved over the area: area of moderate height, much shorter than the width of the shell, vertically striated, well defined at its junction with the exterior of the shell, which curves inwards, occupying a portion of the space.

"Surface marked by more or less regular concentric lamellose folds or wrinkles and radiating striae, extending into long bristle-form spines from the edges of the folds, which are strongly punctate when the shell is partially exfoliated; and when still farther exfoliated, the entire surface is strongly striated."

It should be added that the spines of this species are long, double-barreled and have barbules along their sides. The species was described from the Keokuk limestone.

Localities.—Bedford, Bloomington.

Our specimens differ from the typical form of the species. Some of those from Bedford and Bloomington are intermediate in form between this species and *R. setigerus* Hall, while those from Lanesville are typical specimens of the latter species. Those from

Spergen Hill may be either so far as the fragmentary material is concerned.

No measurements are given with Hall, or Hall and Clarke's descriptions. Their figures, however, give the following proportions of length into breadth: *R. setigerus* 1.1 and 1.16, average 1.13. For *R. pseudolineatus* 1.3 and 1.25, average 1.27. The specimens from Bedford give 1.24, 1.16, 1.157, average 1.189, or approximately 1.19. A specimen broken in half from the "St. Louis Limestone, Lanesville, Indiana," has the proportion of 1.1, or the typical *setigerus* form. In other respects it is like the typical *R. setigerus* Hall. In this specimen the relation of the height of the beak to the length of the shell is 4.83; into the width is 5.17. In the large specimen from Bedford, already mentioned, these same relations are 6 and 5.5, respectively, showing the height of the beak to be much less in proportion to the other dimensions than in *R. setigerus*. It might be stated here for comparison that a specimen from the Harrodsburg limestone, below the Salem limestone, and ordinarily referred to the "Keokuk," gave 1.32 as the relation of the length to breadth.

From these comparisons it will be seen that the specimens from this horizon are intermediate in form between the two species, as is the horizon from which they are taken. I believe that the specimens from the Salem limestone at Bloomington and Bedford appear more like *R. pseudolineatus* than *R. setigerus*, and they are provisionally classed with that species, while the Lanesville specimens are referred to the latter species. It is probable that when very large numbers of specimens are collected from this horizon they will show nearly all the variations from the one species to the other.

#### RETICULARIA SETIGERUS Hall.

Plate XXI, figs. 1-1a.

*Spirifer setigerus* Hall, Geol. Rep. Iowa, I, pt. II, p. 705, pl. XXVII, ff. 4a, b, 1858.

"Shell depressed orbicular, gibbous on the umbones: cardinal line shorter than the width of the shell below. Dorsal valve broadly elliptical, elevated in the middle by an undefined mesial fold, prominent on the lower half of the shell, becoming obsolete before reaching the beak; beak incurved, with a broad foramen



below and distinctly defined area, which is sharply limited by the exterior shell. Pedicle valve a little more convex on the umbones than the brachial valve: mesial sinus reaching the beak in a narrow depression, which becomes deeply marked below the middle of the shell; umbo prominent, rounded, with the beak curving over the foramen; area high, short, contracted by the encroaching of the exterior shell, which curves inward along the margins, vertically striated: foramen large, wider at base than the length of the side." (Hall, slightly emended.)

Localities.—Lanesville, Bedford. See discussion of previous species.

*EUMETRIA MARCEYI* Shumard.

Plate XXII, figs. 28-30.

*Terebratula serpentaria* Owen, Geol. Rep. Wis., Ia. and Minn., tab. 3a, f. 13, 1852. (Not deKoninck.)

*Terebratula marceyi* Shumard, Marcy's Exp. Red Riv., p. 177, pl. I, ff. 4a, b, 1854.

"Shell longitudinally ovate; valves almost equally convex; dorsal (ventral) valve most prominent near the beak, which is elevated and incurved so as to bring the circular foramen nearly on a line with the margins and valves; foramen round; ventral (dorsal) valve smaller, auriculated on the cardinal angles, beak small, scarcely rising above the straight cardinal margin; area small, triangular, not entirely confined to the larger valve, bounded by a distinct angular margin. Surface longitudinally striate, marked by fifty rounded, beautifully punctate, simple striae. Length .10 to .32, width .08 to .27 of an inch, usually. Some specimens have a length of three-fourths of an inch." (Hall.)

Localities.—Lanesville, Spergen Hill, Bedford, Bloomington, Paynters Hill, Harrodsburg, Stinesville, Romona.

"There is a very strong resemblance between the larger individuals of this species and specimens of *Eumetria* (*Retzia*) *vera*, Hall (Geol. Rept. Iowa, 1858, p. 704, pl. 27, fig. 3), but the latter species is not so ventricose, has not the beak so strongly incurved, has a larger cardinal area, and usually but not always stronger surface radii. The present form often attains a considerable size, especially those from Paynter's Hill, and sometimes become extremely ventricose." (Whitfield.)

## ATHYRIS DENSA Hall and Clarke.

Plate XIX, figs. 2-2c.

*Athyris densa* Hall and Clarke, 13th Rep. N. Y. State Geol., p. 651, 1894.

"Shell transversely elongate, valves compressed; median fold and sinus not well developed. Pedicle valve shallow, with broad, sharply angled cardinal slopes, greatly thickened interiorly. The anterior margin is frequently extended into a linguat process at the termination of the median sinus. Brachial valve the more convex, with an indistinct, flattened and sometimes broadly grooved median fold with regular and even lateral slopes. In the interior of the valves the form of the muscular scars is normal, though there is a notable variation in the size of the adductor scars."

Localities.—Lanesville, Spergen Hill.

The "cardinal slopes" are produced by the thickening of the shell in the cardinal region. By this character this species can readily be separated from worn specimens of *Cleiothyris hirsuta*, with which it is associated, when the surface marks of the latter are removed by weathering.

This species is probably the same as was described by Whitfield as *Centronella crassicardinalis* as suggested by Schuchert. However, I can not be certain of this, as no typical specimens of the form described by Whitfield occur in our collections. From the type locality, though, twenty good specimens of *A. densa* were secured. I think the two are synonymous.

## CLEIOTHYRIS HIRSUTA Hall.

Plate XXII, figs. 18-21; Plate XIX, figs. 1-1a.

*Athyris hirsuta* Hall, Trans. Alb. Inst., IV, p. 8, 1858.

"Shell varying in form from ovate to sub-circular; beak prominent, slightly extended, front compressed, sometimes faintly sinuate. Valves nearly equally convex, the pedicle valve most convex toward the beak; beak of pedicle valve prominent, incurved so as to bring the minute foramen nearly on a line with the margin of the shell; beak of the smaller valve closely incurved beneath the beak of the opposite valve. Surface ornamented by concentric imbricating lamellae, which give origin to successive rows of minute spines.

"The cast shows faint impressions of radiating striae, which are not visible on the external surface of the shell. A narrow impressed line is sometimes shown down the center of the cast of the pedicle valve; and a few specimens have a shallow depressed groove down the center of the shell from the beak to the base of both valves. A cast of a large individual shows about seven turns of the internal spire.

"From the foregoing description it will be seen that this species is closely related to the *Terebratula royssii* of Leveille, and to *T. planosulcata* of Phillips. It differs from the first in its small size and more ovate form, especially of the young individuals, and in never having the distinct sinus possessed by that shell; while the beaks of our shell are more prominent and the slope of each side is less concave. The volutions in the internal spire in *T. hirsuta* are not more than half the number represented in *T. royssii*. From the *T. planosuleata* it differs in its small size, in being less ventricose, especially towards the front margin, in the proportionally more prominent beaks and generally more elongate form. From the specimens examined the projecting spinose lamellae in our shell are never so much extended as in that species." (Hall, slightly emended.)

Localities—Lanesville, Paynters Hill, Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville, Romona, Alton, Ill.

"Specimens of this species obtained in later collections are very much larger than those originally used, some of those marked Spergen Hill measuring nearly three-fourths of an inch in diameter. Comparing these larger individuals, there is no perceptible difference between them and specimens of *Athyris sublamellosa*, Hall, from the Chester limestones. The figured specimen of the latter species, as given in the Geol. Rept. Iowa, 1858, pl. 27, fig. 1, has a very ventricose dorsal valve; this, however, is by no means a constant character, and some of the Spergen Hill examples are fully as ventricose on that side. The Chester examples also develop, in extreme large growth, a deeper sinus and fold, but this feature is not seen in specimens when of the size of the large ones from Spergen Hill. I can see no essential distinction either between these and specimens from the Keokuk limestones usually referred to *A. planosulcata*, Phillips." (Whitfield.)

In addition to these marks it should be pointed out that the range of *royssii* as now understood (see Schuchert's bibliography), includes the horizon from which *C. hirsuta* comes. The only reason why I have not included this species in the synonymy of the former is that most of my comparisons with *C. royssii* have been from figures and descriptions rather than specimens. With the specimens in hand it might be possible, though I think not, to discover some distinguishing features, as was the case with *Spirifer bifurcata* and *Spiriferina norwoodana*.

#### SEMINULA TRINUCLEA Hall.

Plate XXII, figs. 22-27.

*Terebratula trinuclea* Hall, Trans. Alb. Inst., IV, p. 7, 1856.

"Shell subpentagonal or ovate, robust; trilobate, lobes nearly equal; valves nearly equal, the pedicle one gibbous toward the beak, a sinus in the center, beginning above the middle of the valve, gradually becoming wider and deeper towards the base, in some specimens distinctly bounded by an obtusely angular ridge. Brachial valve varying from sub-circular to transversely oval and longitudinally ovate, most convex between the center and the beak, and distinctly trilobate, lobes extending about half way to the beak; the middle lobe often marked by a distinct linear depression; beak of the pedicle valve strong, rounded and incurved, truncated vertically by a distinct rounded foramen. Surface marked by fine concentric lines, which undulate with the lobes, and are extremely sinuous near the margin of the shell. Old shells are often marked by strong imbricating lamellae at unequal distances. Length .20 to .51, width .19 to .46 of an inch."

Localities.—Spergen Hill, Bloomington, Lanesville, Paynters Hill, Bedford, Ellettsville, Stinesville.

A species of very variable form, the young specimens not showing the trilobate character.

## PELECYPODA.

BY J. W. BEEDE.

### PTERONITES SPERGENENSIS Whitfield.

Plate XXIII, fig. 1.

*Pteronites spergenensis* Whitfield, Bull. Amer. Mus. Nat. Hist., I, p. 56, pl. VII, f. 1, 1882.

"Shell very inequilateral and oblique. Hinge-line a little less than the length of the body of the valve, marked by a narrow, linear or cardinal ligamental area. In the left valve the anterior wing is of moderate size, elevated on the surface and rounded on the margin, separated from the body of the shell by a moderate depression; posterior wing large, pointed at the extremity, depressed on the surface so as to bring it entirely below the body of the valve; outer margin broadly sinuate. Body of the valve very ventricose, becoming almost subangular along the umbonal region. Beak large, prominent and projecting beyond the line of the hinge. Right valve unknown. Surface of the left valve marked by proportionally very strong concentric, lamellose striae, which are very regular in their distances and elevated so as to present almost the character of ridges on the body of the shell. Length of the largest specimen observed, measured along the body of the shell, about .33, height .20 of an inch."

Localities.—Spergen Hill, Bloomington, Harrodsburg.

### NUCULA SHUMARDANA Hall.

Plate XXIII, figs. 2-6.

*Nucula shumardana* Hall, Trans. Albany Inst., IV, p. 16, 1856.

"Shell obliquely ovate or sub-cuneate, gibbous towards the beaks; beaks anterior, elevated, approximate or in contact; anterior end vertically truncate; posterior side cuneate, sloping from the beak; cardinal line forming an angle of about 80 degrees at the beak; base forming a broad curve from the anterior and posterior cardinal margins. Surface marked by regular equidistant,

sub-imbricating striae, rarely with unequal concentric folds. Hinge-line somewhat strongly crenulate; ligamentary pit distinct, triangular." (Hall.)

"Length .99 to .21, width .08 to .17 of an inch."

Localities.—Lanesville, Spergen Hill, Harrodsburg, Bloomington, Ellettsville, Romona, Stinesville.

"A very pretty species, and very closely resembling *N. parva*, McChesney, from the Coal Measures, both in size and form. In form it is very constant, the figures given being of the extremes found in the collection. The surface structure offers more variety, as some individuals are very regularly marked and others are covered with strong varices, marking stages of growth. The dentition as obtained from separated valves is shown in fig. 6, pl. 7, the teeth forming rounded tubercles." (Whitfield.)

#### NUCULANA NASUTA Hall.

Plate XXIII, figs. 7-9.

*Nucula nasuta* Hall, Trans. Alb. Inst., IV, p. 17, 1858.

"Shell sub-ovate, abruptly contracted in front; posterior extremity rounded; beaks prominent, sub-central; anterior side shortest and contracted both laterally and vertically into a proboscidal extension. Surface marked by regular lines of growth.

"Length .14, width .09 of an inch." (Hall.)

Localities.—Spergen Hill, Ellettsville, Stinesville, Romona.

"In the above description the posterior side is referred to as anterior. In a specimen of very much larger size, obtained from later collections (fig. 9), the proportions of parts are somewhat different from those of the type individuals, the posterior extension is less marked and the shell proportionally higher." (Whitfield.)

#### CYPRICARDINIA INDIANENSIS Hall.

Plate XXIII, figs. 10-14.

*Cypricardia indianensis* Hall, Trans. Alb. Inst., IV, p. 18, 1858.

"Shell elongate-ovate, narrow and rounded in front; posterior end broader, somewhat compressed and subulate; base broadly curved; hinge line straight, less than the greatest length of the shell; a line or groove on the inner margin extending from the

beak to the posterior extremity; beaks very small, near the anterior end; umbonal ridge gibbous. Surface marked by distinct, regular, imbricating lamellæ.

"Length from  $\frac{1}{8}$  to  $\frac{3}{4}$  of an inch." (Hall.)

Localities: Lanesville, Spergen Hill, Bedford, Harrodsburg, Bloomington, Ellettsville, Stinesville, Paynters Hill, Alton, Ill.

#### CONOCARDIUM CATASTOMUM Hall.

Plate XXIII, figs. 15-17.

*Conocardium catastomum* Hall, Trans. Alb. Inst., IV, p. 13, 1858.

"Shell very small, elongate, suncylindrical or subclavate, gibbous in the middle; beaks minute, rising slightly above the hinge line, and anchylosed, anterior end obliquely truncated and obtusely angular on the umbonal slope; the anterior tubular wing minute; posterior end much extended, and constricted near the middle, swelling at the extremity and gaping below. Surface marked with small simple radiating folds which sometimes become obsolete on the anterior end and umbones. Minute undulating concentric striæ cross the radiating folds in well preserved specimens.

"Length, from .125 to .20 of an inch." (Hall.)

Localities: Spergen Hill, Harrodsburg, Bloomington, Stinesville, Ellettsville, Romona.

"The most peculiar feature of this species consists in the anchylosis of the valves along the hinge margin. Between the beaks there occurs a small tubercle of solid deposit, firmly uniting them, and often extending along the hinge in the form of a callus. This feature not only occurs in adult individuals, but is also seen on many of small size to so great an extent as to have apparently precluded the possibility of any motion of the valves along the cardinal line. From the examination of a large number of individuals I believe, however, that the feature is caused by a deposit of compact, crystalline carbonate of limes on the inside of the shell after death, which has to some extent forced the beaks asunder and filled the space. On the removal of the chalky substance of the shell this layer is exposed, thus producing the appearance of anchylosis. In cutting specimens across at the beaks this feature is readily seen in section, the layer of carbonate of

lime lining the entire extent of the shell. The idea of a perfect anchylosis of the beaks of a bivalve, it appears to me, is incompatible with the further growth of the shell, and especially so where there is a long hinge line. If in the case of this shell the apparent soldering of the valves at the beaks and along the hinge had occurred, they never could have been separated in front for the admission of water or additional growth, and would as a matter of fact resulted in the death of the animal. The minute size and peculiarly constricted form of the species, sometimes in the younger stages of growth being almost cylindrical, is a very marked and distinguishing character of the species." (Whitfield.)

CONOCARDIUM CARINATUM Hall.

Plate XXIII, figs. 18-19.

*Conocardium carinatum* Hall, Trans. Alb. Inst., IV, p. 14, 1858.

"Shell sub-trigonal, gibbous in the middle, anterior end cordate; hinge line straight; beaks very small, strongly incurved, rising little above the hinge line; posterior side straight above, sloping upwards from below, gradually tapering to the extremity, faintly constricted at its junction with the body of the shell and gaping below; hiatus elongate-lanceolate, crenulate; umbonal slope strongly carinated; carina reaching from the beak to the base, where it is strongly salient; anterior side obliquely truncate, and abruptly produced into a small conical tubular extension of the hinge line. Surface marked by simple radiating ribs and extremely fine concentric striae, which in passing over the ribs give the surface a granulated appearance. On the anterior slope the ribs are finer and closer than on the sides of the shell, and strongly curved.

"Length, from .20 to .33 of an inch." (Hall.)

Localities: Spergen Hill, Bloomington, Harrodsburg, Stinesville.

"The carina which forms the crest along the anterior umbonal ridge constitutes the distinguishing feature of this form. In other respects it does not appear to differ from *C. cuneatum*, Hall; and, as many specimens are found which are intermediate between the typical specimens of the two, it is probable they are only varieties of one species." (Whitfield.)



## CONOCARDIUM CUNEATUM Hall.

Plate XXIII, figs. 24-26.

*Conocardium cuneatum* Hall, Trans. Alb. Inst., IV, p. 14, 1858.

"Shell sub-trigonal or abruptly calvate; hinge line straight; beaks anchylosed, incurved, very small, rising but little above the hinge line; umbonal slope angular; anterior side truncate, concave just within the angle of the umbonal slope, convex in the middle abruptly produced above, in continuation of the hinge line, in a tubular wing; posterior side vertically compressed, straight along the hinge line, and abruptly declining at the extremity, sloping along the base from the center of the shell to the extremity. Hiatus elongate, extending forward to near the middle of the shell, rounded and expanded at the posterior extremity, and deeply crenulate in the margins of the narrow part. Surface marked by distinct radiating costae, which often alternate in size or bifurcate on the posterior part of the shell; crossed by fine elevated concentric lines of growth, more or less closely arranged. Near the basal margin are some stronger subimbricating ridges parallel to the lines of growth.

"Length, .33 to .50 of an inch." (Hall.)

Localities: Spergen Hill, Bloomington, Harrodsburg, Stinesville.

"The remark 'beaks anchylosed' as applied to this species can not have the same significance as it does in the case of *C. catastomum*, as the most perfectly preserved specimen in the collection has the beaks clean, clear and perfectly free from each other, without any deposit or thickening of any kind between them. The suture of the hinge between the beaks and elsewhere is sometimes very close, and in some cases where the shells have been dead and eroded previously to being imbedded, the line has become entirely obliterated by emaceration. This I presume is what is meant by the statement. The hiatus, or gaping of the valves on the postero-basal line, is sometimes very marked and the thickening of the internal ribs so prominent as to form strong interlocking teeth along the narrow part of it." (Whitfield.)

## CONOCARDIUM PERATTENANUM Hall.

Plate XXIII, fig. 20.

*Conocardium perattenanum* Hall, Trans. Alb. Inst., IV, p. 15, 1858.

"Shell sub-fusiform; hinge line straight, beaks depressed, distinctly anchylosed; from the beaks along the anterior umbonal slope, angle obtuse and scarcely defined; anterior side obtuse, convex in the middle, and gradually sloping upwards from the angles; posterior part of the shell with a broad depression on each side, and again expanding at the extremity with an oblique angular fold, from the hinge line downwards to the hiatus; hiatus broad and expanded behind, narrowed abruptly at the junction of the oblique folds, and thence gradually to the middle of the shell. Surface marked by strong plications, which are much stronger on the anterior part of the shell, and more slender behind. The fold along the anterior umbonal slope bifurcates, sending off on each side a plication, which again bifurcates. Plications crossed by sharply elevated lines, which are more conspicuous on the posterior part, giving it a cancellated appearance.

"Length, .20 of an inch." (Hall.)

Localities: Harrodsburg, Alton, Ill.

"The beaks and upper part of the anterior face of the valves are imperfect, and the apparent anchylosis may be and probably is deceptive. The species is a very distinct and well marked one, differing materially from all the others in the collection in the few strong plicae of the anterior end, and the stronger bifurcating plications of the anterior umbonal ridge." (Whitfield.)

## CONOCARDIUM MEEKANUM Hall.

Plate XXIII, figs. 21-23.

*Conocardium meekanum* Hall, Trans. Alb. Ins., IV, p. 15, 1858.

"Shell sub-angularly ovate or abruptly clavate; hinge line nearly straight, declining at the posterior extremity and sometimes from the beaks; obliquely truncated anteriorly; anterior end convex in the middle, and margined by a narrow sulcus which reaches from the beak to the base just within the obtuse angle of the umbonal slope; posterior end sloping on the base uniformly from the center of the shell to the extremity, contracted behind the body of the

shell; vertically depressed and slightly expanded laterally at the extremity. Surface marked by small, elevated, thread-like radiating lines, which on the posterior part of the shell are crossed by fine concentric striae, giving that part of the shell a cancellated appearance. Anterior depressed end marked by much fainter radiating lines crossed by nearly obsolete traces of fine striae, which converge towards the anterior tubular wing.

"Length, .20 to .33 of an inch." (Hall.)

Localities: Alton, Ill.

"The shells of this species bear considerable general resemblance to those of *C. cuneatum*, but are generally smaller. They vary considerably among themselves, as do those of that species. The one figured is of the broadest and most obtusely cuneate form; others being very much more slender and the umbonal ridge more oblique. One distinguishing feature between the two is in the coarser striae marking the anterior end of the shell of this one, which are not regularly concentric, as in *C. cuneatum*, but successively diverge from the umbonal ridge. The material in which the shells are preserved is well calculated to retain all the surface markings, and consequently the cancellation of the surface is beautifully preserved." (Whitfield.)

#### CONOCARDIUM EQUILATERALE Hall.

*Conocardium equilaterale* Hall, Trans. Alb. Inst., IV, p. 16, 1858.

"Shell triangular, sub-equilateral, scarcely gibbous in the middle; hinge line very straight; beaks small, rising a little above the hinge line; anterior end cuneate, sloping gradually from near the center of the shell; umbonal ridge obtuse above, nearly at right angles to the hinge, and subdividing several times before reaching the base; posterior end cuneate, very gradually sloping from the body of the shell; extremity unknown. Surface marked by radiating striae or folds, which are simple or bifurcating, and crossed by fine, regular, elevated, thread-like lines.

"Length and width nearly equal, about .125 of an inch." (Hall.)

"Only a single individual of this species was obtained in all of the collections examined, and this has not been found in the col-

lection since it came into the possession of the Am. Mus. Nat. History. Consequently I have not been able to give illustrations of the species." (Whitfield.)

MICRODON SUBELLIPTICA Hal.

Plate XXIII, figs. 27-29.

*Cypricardella subelliptica* Hall, Trans. Alb. Ins., IV, p. 17, 1858.

"Shell subelliptical, obliquely truncated at the posterior end; beaks minute at the apex, rising little above the hinge; umbones sub-gibbous, with an undefined elevation extending obliquely towards the posterior basal margin; anterior end narrower than the posterior, rounded at the extremity. Cardinal margin forming an angle with the beak of  $25^{\circ}$ ; base forming a regular elliptical curve. Surface marked by regular, fine, concentric elevated lines which are equal to the spaces between.

"Length, .19 to .32; width, .14 to .24 of an inch." (Hall.)

Localities: Spergen Hill, Harrodsburg, Bloomington, Stinesville.

"The proportionally greater height or shorter form, with rounded antero-basal and posterior margins, will sufficiently distinguish this one from either of the other species associated with it." (Whitfield.)

MICRODON OBLONGA Hall.

Plate XXIII, figs. 30-36.

*Cypricardella oblonga* Hall, Trans. Alb. Inst., IV., p. 18, 1858.

*Cypricardella nucleata* Hall, Ibid., p. 17.

"Shell oblong, sub-quadrangular; anterior end narrow, rounded; posterior end broader, flattened, and almost vertically truncate; cardinal margin nearly straight and horizontal behind, declining in front; base nearly parallel to the hinge line; beaks small, somewhat prominent, gibbous below; posterior umbonal slope gibbous or sub-angular, and extending obliquely downwards and backwards to the base of the truncation; lunule small, ovate, deep in the center; escutcheon linear, distinct.

"Length, .09 to .30; width, .06 to .20 of an inch." (Hall.)

Localities.—Spergen Hill, Harrodsburg, Bloomington, Ellettsville, Stinesville, Paynters Hill.

"This species occurs of larger size than any of the others associated with it. When small it is nearly equally high and long, but becomes gradually longer in proportion as it increases in size, so that specimens are often found much more than half as long again as high. In the Geol. Rept. Iowa, 1858, pl. 23, fig. 10, a specimen of this species is figured as *C. nucleata*, probably by mistake. The specimen is one of the original series, and has always been attached to the card marked *C. oblonga*. It corresponds exactly in size to the measurements given of that species in the original description, being .30 of an inch long and .20 of an inch wide; while no measurements are given of *C. nucleata* exceeding one-half that width, and but little more than one-third the length." (Whitfield.)

In discussing *M. nucleata*, Whitfield states that: "This is the smallest form observed, and is of nearly equal height and length in its typical form, but specimens of larger size are proportionately longer, as they increase more in length than in height with increased growth. In consequence of this feature it becomes very difficult if not impossible to distinguish between medium sized individuals of *M. oblonga* and large individuals of this species, and leads one to suspect that they may both belong to one species, especially as the surface markings bear the same proportions to the shell as do those of that species when of the same size."

There can be but little doubt that the small species is the young of the larger one.

#### MICRODON ELLIPTICUS Whitfield.

Plate XXIII, fig. 37.

*Microdon (Cypricardella)* sp.? Whitfield, Bull. Amer. Mus. Nat. Hist., I, p. 65, pl. VII, f. 37, 1882.

"Several small examples resembling *M. oblonga* in its proportions of length and breadth, and having an elliptical outline corresponding to that of *M. subelliptica*, have been observed among the later collections from Spergen Hill. It does not appear to be distinct enough from either of the forms to be entitled to rank as a distinct species, but appears to unite the two. A figure of one

of them is given that attention may be directed to it, with the hope of obtaining further information." (Whitfield.)

So far as examined at present our Spergen Hill material does not show any specimens of this variety, though it will doubtless be found. For this reason I am unable to throw any more light on the subject now.

GONIOPHORA? PLICATA Hall.

Plate XXIII, fig. 39.

*Cypricardella plicata* Hall, Trans. Alb. Inst., IV, p. 18, 1858.

"Shell oblong, sub-quadrate, hinge line slightly arched, the base and hinge line nearly parallel; gibbous in the middle above, and anteriorly, depressed in the middle towards the base; the beaks near the anterior end, small, and scarcely rising above the hinge margin; anterior end short, scarcely extending beyond the beak, rounded; posterior extremity double truncate; a strong fold or angulation extending from the umbo to the posterior basal margin, and a smaller similar fold midway between that and the hinge line, the intervals on the margins between these being truncate. Surface marked with concentric lines of growth.

"Length, .12, width, .12 of an inch." (Hall.)

Localities: Spergen Hill, Bloomington, Stinesville.

"The hinge margin of this species is bounded by a narrow escutcheon, and the ligament has been external. These features, together with the general form of the shell, would throw it into the genus *Goniophora* unless the hinge features may differ, which is scarcely probable. The only other genus to which it has much resemblance is *Pleurophorus*, to which externally, however, it is not so closely related." (Whitfield.)

EDMONDIA? SUBPLANA Hall.

Plate XXIII, fig. 38.

*Cypricardia subplana* Hall, Trans. Alb. Inst., IV, p. 19, 1858.

"Shell ovate oblong; anterior end very short; posterior end extremely elongate, very gradually narrowing to the extremity which forms a symmetrical elliptical curve; cardinal and basal margins nearly parallel; beaks small; umbonal region depressed convex.

A few obsolete concentric folds on the surface; intermediate portions probably finely striate.

"Length, .69; width, .38 of an inch." (Hall.)

Localities: Lanesville, Spergen Hill, Bloomington, Romona.

"All examples of this species which have been observed have been imperfect. The type specimen is very much water-worn, and although the hinge margin of the shell is very well exposed, it presents no dentition whatever. A second specimen of about the same size, a partial cast, shows a rather large posterior muscular imprint situated near the cardinal margin; but the anterior end is more imperfect. The structure of the hinge so far as revealed, a simple margin with probably an external ligament, will come nearer to the characters of the genus *Edmondia* than to any other known carboniferous form. It certainly is not *Cypricardia*, as that genus is known from recent species." (Whitfield.)

#### MACRODON? SP.

Plate XXIV, fig. 2.

Shell of rather large size, about twice as long as high, thickness about one-third the height. Greatest height near the posterior extremity. Outline roughly semielliptical, hinge straight, shorter than the greatest length of the shell, posterior extremity rounded, meeting the hinge at an obtuse angle, more sharply rounded to the ventral margin, which is slightly sinuous just below and a little back of the beak, rounding abruptly upward and then backward a little, meeting the hinge at a slightly obtuse angle. Beaks prominent, rising somewhat above the hinge, sloping gradually away to the postero- and antero-ventral margins, with a broad, undefined depression between them extending obliquely downward and backward. Surface apparently smooth except for growth varices. The specimen is not so preserved as to show any but very strong markings. One left valve, loaned by the American Museum.

Length, 33 mm.; height, 16 mm.; thickness, 11 or 12 mm.

Locality: Spergen Hill.

This specimen differs from *M. obsoletus*, in having relatively shorter hinge line and in having growth lines at the extremities, indicating that it had a semielliptical outline. The growth lines

join the hinge at quite an obtuse angle, rather than nearly at right angles.

The generic affinities of this shell are determined only by the outer expression of the valve, as none of the critical characters of the hinge can be seen. It seems to resemble the species of *Macrodon* more than those of any other genus.



# GASTEROPODA, CEPHALOPODA AND TRILOBITA OF THE SALEM LIMESTONE.

BY E. R. CUMINGS.

## GASTEROPODA.\*

[Genus ORTHONYCHIA Hall.]

[ORTHONYCHIA ACUTIROSTRE (Hall) Keyes.]

Plate XXIII, fig. 14; Plate XXV, figs. 13-15.

*Platyceras acutirostris* (*Capulus acutirostris*) Hall, Trans. Alb.  
Inst., IV, p. 31; Geol. Rept. Iowa, 1858, p. 665.

"Shell obliquely conical, more abruptly contracted above, and continued in more slender proportions to the apex, which is incurved, making about a single volution without contact with the body of the shell; aperture sub-circular, margin sinuate, surface sub-plicate, with narrow subangular folds and wider depressed spaces; lines of growth strong, abrupt upon the angles and arching forward on the spaces between."†

There is a very great degree of variability among the specimens of this species, even at the typical localities, and particularly so when a more extended geographical distribution is considered. In the degree of expansion of the shell it is particularly variable, and also in the number and arrangement of the plicae and consequent sinuses of the margin. The apex of the shell may also be short and minute, or long, pointed or enrolled. [Referred to *Orthonychia* by Keyes, Geol. Mo. V.]

[\*Whitfield's valuable paper on the "Spargen Hill" fauna has not reached as wide a constituency of Indiana scientists as could have been wished, hence the present paper is intended to do little more than republish his excellent figures and descriptions with such additional comment and changes in nomenclature as are deemed necessary. The principal additions are in the way of new localities. Several new species are described, one of them, *Subulites Harrodsburgensis*, a very abundant form which has probably escaped detection owing to its close resemblance in its usual state of preservation to certain sea-urchin spines. The writer would have been glad to have revised the species here placed in the genera *Pleurotomaria* and *Murchisonia*; but such a revision would involve a restudy of all Carboniferous forms, an undertaking impossible in the brief time allotted for the work.

All additions and descriptions by the present writer are enclosed in brackets.]

†The portions in quotation marks are from Hall's original paper (quoted by Whitfield). The balance, except portions in brackets, is by Whitfield.

Localities: Spergen Hill, Paynters Hill, Ellettsville, [Harrodsburg], Bloomington, [Stinesville, Romona], and Crawfordsville, Ind.; Warsaw and elsewhere in Illinois, and Tuscumbia, Alabama.

Genus LEPETOPSIS [Whitfield].

Shell patelliform, more or less regularly round or oval, apex sub-central, posterior to the middle and directed backward, the nucleus dextrally coiled; muscular imprint horseshoe-shaped, open (?) in front, consisting of an irregular narrow band which expands more or less at the anterior extremities. Surface of the shell marked by six very indistinct radiating lines, two anterior, two posterior, and two lateral. Type *L. Levettei* White.

It seems as if there were already genera enough among the shells of this group to include any new form that might be discovered, but there is certainly need of some designation other than any existing one, under which forms of this kind that are comparatively numerous in the carboniferous limestones can be placed. They have been usually called *Patella* or *Capulus*, and are often doubtfully referred to *Metoptoma*, but it is quite certain they do not properly belong to either of these genera. *Metoptoma* proper is a very distinct form, and Prof. Phillips, even when proposing that genus, referred forms congeneric with this one to *Patella*. It certainly seems like straining a point to refer these carboniferous shells to a living genus, simply on their general form, when among the living ones such diverse characters are found in the animals as to require several genera, where the shells are undistinguishable from external form alone. I have therefore preferred to risk proposing a new name rather than to refer them to a genus to which I am certain they do not belong. I am slightly in doubt concerning the opening in the muscular impression on the anterior side, as I have not been able to fully see this part. The genus bears some relation to *Anisimyon* M. & H. (see Invert. Pal. U. S. Geol. Surv. Territ., p. 285) in its general appearance, but the nucleus is not reversed and the radiating lines are external, while those of that genus appear strongest on the inside, as ridges.

## LEPETOPSIS LEVETTEI (White) Whitf.

Plate XXV, figs. 9-12, and fig. 8.

*Lepetopsis levettei* (*Patella levettei*) White, Geol. Ind., 11th Rep., p. 359, pl. 39, figs. 4 and 5.

Shell nearly regularly oval in outline, moderately to depressed convex; apex minute, slightly posterior to the middle of the length; anterior end of the shell more highly convex than behind, the latter portion slightly concave just behind the apex; shell somewhat lamellose in structure and marked by concentric lines of growth; the radiating lines which mark the surface are very faint or obsolete; when seen they divide the shell into six nearly equal parts; length of largest specimen 1.1 inch; width a little less than 1 inch.

In the collection there are two shells, one of which is represented by fig. 8, which appear to be the apical portions of a larger specimen; but possibly they may belong to this species, as both individuals figured show that the apex has been less rapidly expanding than the shell below. It is possible they may represent a distinct species, but they appear so immature that I hesitate to consider them in that light.

Locality: Spergen Hill, Ind.

[Genus STRAPAROLLUS Montfort.]

## STRAPAROLLUS SPERGENENSIS (Hall).

Plate XXV, figs. 16-19.

*Euomphalus spergenensis* Hall, Trans. Alb. Inst., IV, p. 19.

*Straparollus spergenensis* (Hall) S. A. Miller, Cat. Am. Pal. Foss.

"Shell sub-discoid or planorbiform; spire composed of five or six turns, the inner ones coiled in the same plane, two or three of the outer ones only visible in profile; suture well defined on both sides; volutions rounded below with a distinct obtuse angulation on the upper side, a little distance from the suture; umbilicus nearly twice the breadth of the outer volution; aperture oblique, round-oval, with a slight expansion at the angle on the upper side of the volution. Surface marked by close, fine, equal striae of growth.

"Diameter, .30 to 1 inch; height, .23 to .45 of an inch.

"This shell resembles the *E. lævis* of D'Archiac and DeVerneuil (Trans. Geol. Soc. Lond., vol. VI, 2d series, part 2, p. 363; pl. 33, fig. 7). *E. planorbis* in part of De Koninck. (Carb. Fossils of Belgium, p. 434, pl. 25, fig. 7.)

"Our shell agrees with the description of MM. D'A. and DeV. with the exception of the form of the aperture. The figures given by these authors show the greatest diameter of the aperture to be transverse, while in the species here described the longest diameter is obliquely outwards and downwards from the axis of the shell. Our shells with five turns of the spire are much smaller than *E. lævis* of these authors, and our larger specimens are precisely of the same size as the four inner volutions of their figure.

"It is possible, however, that these deviations which appear constant in our specimens may prove to be only a variety not of specific value. Our specimens of this species, which are numerous, do not lead us to include the *E. planorbis* of D'A. and DeV. as a variety."

The shells of this species are extremely variable, and where large collections of the various stages of growth are examined together, it becomes totally impossible to draw lines of distinction between this and the other three forms associated with it. The var. *Planorbiformis* differs only in the depression of the spire to nearly the plane of the outer volution, the number of volutions even here varying considerably. *E. planispira* has the volutions more slender as well as more numerous, and often the spire becomes so depressed as to present but very little difference between it and the umbilical side. The form originally given as *E. quadrivolis* is perhaps more distinct and more readily distinguished than any of the others, still intermediate forms are so numerous as to cause great trouble in separating it from the more rapidly expanding specimens of *E. spergenensis*. As the surface markings are alike in all the four varieties, it becomes a question as to whether they may not all belong to one very protean species. However, as they have been described as distinct forms I have given illustrations of each, that others may form their own conclusions.

Localities: The typical form of *E. spergenensis* has been observed at Spergen Hill and Paynters Hill, Bloomington and

Ellettsville, Ind. The other forms have been observed at each locality mentioned except Ellettsville, where it is possible they may occur, as I have seen but few specimens from that locality. [All forms occur at Ellettsville, as also at Stinesville and Harrodsburg, Ind.]

*Euomphalus spergenensis* var. *planorbiformis* Hall, Trans. Alb. Inst., vol. IV, p. 20. *Straparollus spergenensis* var. *Planorbiformis* (Hall) S. A. Miller, Cat. Am. Pal. Foss. Pl. 25, figs. 20 and 21.

"Shell discoid; spire flat or concave; volutions about four, rounded above and below; aperture nearly circular; umbilicus broad, not deep."

*Euomphalus planispira* Hall, Trans. Alb. Inst., vol. IV. p. 20. *Straparollus planispira* (Hall) S. A. Miller, Cat. Am. Pal. Foss. Pl. 25, figs. 22 and 23.

"Shell discoid; spire flat or scarcely concave; volutions about five or six, slender, very gradually increasing in size, rounded above and below; suture well defined; aperture circular; umbilicus broad and shallow. Surface marked by fine, closely arranged and slightly undulating striae.

"Diameter, .36; height, .12 of an inch.

"This shell is distinguished from either of the preceding by its slender volutions which increase much more gradually from the apex. The volutions are round both above and below, though sometimes the lower side descends so abruptly to the umbilicus as to present the appearance of an obtuse or undefined angle on the last volution."

*Euomphalus quadriovolis* Hall (*Trans. Alb. Inst., Vol. 4, p. 19.*) *Straparollus quadriovolis* (Hall), S. A. Miller, Cat. Am. Pal. Foss. Pl. 25, figs. 24 and 25.

"Shell planorbicular, spire depressed, composed of about four turns, the inner one scarcely rising above the last volution; volutions somewhat rapidly increasing from the apex, regularly rounded; aperture round-oval, slightly transverse; umbilicus less than the diameter of the outer volution. Surface marked by fine, closely arranged striae of growth.

"Diameter .12 to .31, elevation .06 to .16 of an inch."

There is so much confusion in regard to the value of the names *Euomphalus* and *straparollus* that I have preferred to leave these species where they were originally placed, rather than to burden the science with additional and useless references by changing them under uncertainty.

[These forms are here referred to the genus *Straparollus* and to the species *S. spergenensis*. There is now no doubt whatever of the correctness of Whitfield's opinion that this is a single protean species. The author has examined thousands of specimens, from a large number of localities, and in any large suite of specimens a separation into the species enumerated by Hall is impossible.]

[Genus STROPHOSTYLUS Hall.]

[STROPHOSTYLUS CARLEYANA (Hall) Keyes.]

Plate XXV, figs. 26 and 27.

*Naticopsis Carleyana* (*Natica Carleyana* Hall; Trans. Alb. Inst., Vol. 4, p. 31.)

"Shell sub-globose; spire short, consisting of about three volutions, which increase very rapidly, the last one extremely ventricose; suture not distinctly defined; aperture ovate, straight on the columellar side; outer lip sharp; inner lip thickened; columella with a distinct groove near the base of the lip for the reception of the operculum; surface marked by fine elevated striae, corresponding to the lines of growth.

"Height .10 to .30, diameter .08 to .34 of an inch."

This species is very closely related to *N. nana*, M. and W., from the Coal Measures of the Western States, and if mingled with specimens of that species of the same lithological character it would be difficult to separate them. The inside of the aperture on the columellar side is thickened, and the shell imperforate, which characters would remove it from the genus *Natica* to *Naticopsis*. Among some later collections there are specimens which measure fully one-half inch in height, being much larger than those in the original collection.

Localities.—Spergen Hill and Bloomington, Ind., and Alton, Ill., being very rare at the latter locality, while extremely abundant at that first mentioned. [Found also at Harrodsburg, Roma, Stinesville and Ellettsville, Ind.]

## Genus MACROCHEILUS Phillips.

Plate XXV, fig. 28.

## MACROCHEILUS LITTONANUS Hall.

*Natica Littonana* Hall, Trans. Alb. Inst., Vol. 4, p. 30.

"Shell short, sub-fusiform; spire depressed-conical; volutions about four, rapidly increasing from the apex, the last volution symmetrically ventricose and prolonged below; suture not strongly marked; aperture narrow-ovate, sharp above, and narrowing near the front; outer lip thin; inner lip thickened; surface striated.

"Height .25, diameter .19; last volution .17 of an inch."

This shell is very erect in form, the columella forming the central axis, unlike any form of *Natica*. The columella of the only specimen in the collection indicates the existence of a very slight twist, showing the features of the genus *Macrocheilus* to which I have referred it. The surface under a strong hand-glass appears to me to be entirely destitute of markings of any kind, and the suture line between the volutions to have been partially obliterated by a deposit like that of the recent *Ancillaria*.

Locality.—Bloomington, Ind.

## [MACROCHEILUS STINESVILLENSIS n. sp.]

Plate XXIV, figs. 10-10a.

Shell robust, smooth; spire short but rather abruptly elevated, conical. Four volutions, the first three small and only slightly convex, the last very large and gibbous. Aperture imperfectly preserved but having the general outlines of the genus. Suture shallow. This species differs from *M. littonanus* in the higher, more abruptly elevated spire and less globular shape of the last volution.

Locality.—Stinesville, Indiana, rather rare.

Indiana University collection.]

## [MACROCHEILUS sp.]

Plate XXIV, figs. 3-3a.

A poorly preserved individual from Spergen Hill is probably referable to this genus.

Indiana University collection.]

## Genus HOLOPEA Hall.

## HOLOPEA PROUTANA Hall.

Plate XXV, figs. 33 and 34.

*Holopea (Callonema?) Proutana* Hall; Trans. Alb. Inst., Vol. 4, p. 30.

"Shell ovate-conical; spire somewhat rapidly tapering; volutions about six; moderately convex, last one ventricose, subangular in the direction of the suture line, and obliquely extended below; suture sharply defined; aperture round-ovate, oblique on the upper side; pillar lip slightly reflexed in the umbilical region; umbilicus none; surface marked by fine striae parallel to the lines of growth.

"Length .62 to .50 of an inch."

There is considerable variation in the ventricosity of the volutions in this species, some of them being decidedly flattened in the direction of the spire, while others are quite round and the suture line very distinct. The angulation at the outer base of the last volution is also often obsolete. The shell is minutely perforate, and has a decided umbilical depression at the top of the columella.

Its generic relations with *Holopea symmetrica*, Hall, the first species of the genus described is not very close, but perhaps as near as to any other described genus. It has exactly the characters of *Callonema*, Hall, as shown in *C. bellatula*, except in the surface ornamentation, which is given by the author as a generic feature, although *C. bellatula*, and especially the New York form of it, known as *C. Lichas*, frequently becomes nearly smooth toward the aperture in old shells.

Localities.—Spergen Hill and Bloomington, Ind., and Alton, Ill. [Also Paynters Hill, Harrodsburg, Ellettsville, Stinesville and Romona, Ind.]

## BULIMORPHA [Whitfield].

Shell fuisiform, spire produced; volutions convex, the last large; columella bent and truncated at the base, where it is separated from the outer lip by a notch as in the recent genus *Achatina*; outer lip very slightly notched near the upper end; surface of the shell smooth. Type *B. bulimiformis*, Hall.



## BULIMORPHA BULIMIFORMIS Hall.

Plate XXV, figs. 37-39.

*Bulimella bulimiformis* Hall, Trans. Alb. Inst., Vol. 4, p. 29;

*Polyphemopsis bulimiformis* (Hall), M. and W., Geol. Rept. Ills., Vol. 2, p. 372.

"Shell fusiform, elongate; spire nearly equal to half the length of the entire shell; volutions about six, slightly convex in the middle, increasing somewhat rapidly, the last one equaling in length all the others; aperture elongate-oval, acute at each extremity, slightly sinuate at the upper outer angle; columella slightly curved and truncate at the base; surface smooth or with faint lines of growth.

"Length .25 to .75 of an inch."

This species is the most common one occurring in these beds, and will be found to vary greatly in the proportional length and thickness as well as somewhat in the ventricosity of the volutions.

Localities.—Spergen Hill and Bloomington, Ind. [Also Paynter's Hill, Harrodsburg, Ellettsville, Stinesville, Romona, Ind. Common.]

## BULIMORPHA CANALICULATA Hall.

Plate XXV, fig. 41.

*Bulimella canaliculata* Hall, Trans. Alb. Inst., Vol. 4, p. 29;

*Polyphemopsis canaliculata* (Hall), M. and W., Geol. Rept. Ills., Vol. 2, p. 372.

"Shell sub-fusiform; somewhat elongate; spire short, scarcely equaling the length of the last volution; volutions about five, upper ones scarcely convex, rapidly diminishing to the apex, last volution longer than the spire above, slightly ventricose; suture canaliculate, the groove margined by a slight sharp carination at the upper edge of the volution; aperture sub-ovate; surface smooth or marked with fine lines of growth, which are abruptly bent backwards at the carination on the upper edge of the volution which marks the notch in the upper angle of the aperture.

"Length .18 of an inch."

The notch mentioned in the above description is not a notch in the lip like that of *Pleurotomaria*, *Murchisomia*, etc., but is formed by the channeling of the suture only. This feature at once distinguishes this from any of the other species described.

Locality.—Spergen Hill, Ind. The locality as given under the original description includes Bloomington, Ind., also. Only one characteristic specimen exists in the collection, that being from Spergen Hill, Ind. [Lanesville, Ind.]

BULIMORPHA ELONGATA Hall.

Plate XXV, fig. 40.

*Bulimella elongata* Hall, Trans. Alb. Inst., Vol. 4, p. 30; *Polyphemopsis elongata* (Hall), M. and W., Geol. Rept. Ill., Vol. 2, p. 372. *Polyphemopsis teretiformis*, Hall; Cat. Am. Pal. Foss., S. A. Miller, p. 245.

“Shell extremely elongate; volutions seven or eight (perhaps nine), somewhat rapidly ascending, moderately convex, the greatest convexity a little above the middle, last one slightly ventricose; suture distinct, an undefined angular elevation below, corresponding to the notch in the lip; surface nearly smooth; direction of the striae scarcely visible.

“Length .50 of an inch.”

The undefined angular elevation below the suture mentioned in the description is remarkably obscure in the type specimen, and corresponds only to the “greatest convexity” which exists “a little above the middle” of the volutions. The species is very rare, nearly as much so as *B. canaliculata*, only the type specimen being found in good condition; a few other worn specimens only having been observed. The change of generic name will restore the original specific name of *elongata*, making it *Bulimorpha elongata*, Hall’s sp.

Locality.—Spergen Hill, Ind. [Lanesville, Ind.]

Genus CYCLONEMA Hall.

CYCLONEMA LEAVENWORTHANA Hall.

Plate XXV, figs. 29-31.

*Pleurotomaria Leavenworthana* Hall, Trans. Alb. Inst., Vol. 4, p. 24.

“Shell ranging in form from sub-globose to terete-conical and elongate-ovate; spire conical, varying greatly in its elevation from the young to the old shell; volutions five to seven, neatly rounded and ventricose below; suture well defined; aperture round-oval;

umbilicus none; surface marked by conspicuous, rounded, revolving striae, which are less than the spaces between; striae less conspicuous on the base of the last volution; the first line below the suture uniformly thinner and sharper than the others, and the spaces on each side wider.

"Length from .05 to .50 of an inch."

This shell is remarkably variable in the degree of expansion of the volution, the apical angle being in some cases nearly twice as great as in others, while the increase in the volution is equally variable. These changes give one the impression, when only a few individuals are examined, that there are two distinct species represented, but so many connecting forms can easily be obtained that one soon abandons this view. The species presents no evidence of being a true *Pleurotomaria*, as there is no indication of a notch between any of the revolving striae. The characters correspond much more nearly to those of *Cyclonema*, Hall, although it lacks the flattening of the columella that is seen in *C. bilix*.

Localities.—Spergen Hill and Bloomington, Ind., and Alton, Ill. [Also Harrodsburg, Ellettsville, Stinesville, Paynters Hill and Romona, Ind. Abundant.]

#### CYCLONEMA SUBANGULATUM Hall.

Plate XXV, fig. 32.

*Pleurotomaria subangulata* Hall, Trans. Alb. Inst., Vol. 4, p. 25.

"Shell ovate-conical; volutions about five or six, angular above, the last one ventricose below; upper side of volution nearly rectangular to the direction of the spire; aperture ovate, the inner side straight or concave; umbilicus none; suture distinct; surface ornamented by unequal, revolving lines, those on the lower part of the last volution finer and more closely arranged, three of those on the periphery stronger and more distant, the upper one of these three stronger than the other two, forming the summit of the angle; midway between the angle and the suture is one strong angular stria, and on the outer side, and sometimes on the inner side of this a finer one."

"Length .35 of an inch."

This shell is closely allied to *C. Leavenworthana*, and will most likely prove to be only a variety of that one. The carinated upper

angle of the last volution is caused by the dropping out of the revolving line below it, and to some extent also that above, causing this individual line to stand out more prominently. In the form of the lower part of the volution and in that of the aperture they agree perfectly.

Locality.—Spergen Hill, Ind. [Harrodsburg, Bloomington and Stinesville, Ind.]

Genus LOXONEMA Phillips.

LOXONEMA YANDELLANA Hall.

Plate XXV, figs. 35 and 36.

Trans. Alb. Inst., Vol. 4, p. 28.

"Shell terete-subulate; spire elongate, very gradually tapering to the apex, which is apparently obtuse; volutions about eight or nine; very little convex, the last one scarcely expanded; suture distinct; surface marked by fine thread-like striae crossing the volutions with a slight undulation above the middle; aperture ovate. "Length .20 to .50 of an inch."

This species has proved to be exceedingly rare, and so far as seen is usually quite small. The fragment figured represents the largest growth yet noticed, while the surface markings are much stronger proportionally than on any other specimen examined.

Locality.—Spergen Hill, Ind. [Also Harrodsburg, Romona and Big Creek (Stinesville), Ind.]

*Loxonema vineta*, see Murchisonia vineta.

The shell described in the original Spergen Hill paper as *Pleurotomaria concava* presents features entirely incompatible with those of any known genus so far as I can ascertain. It is trochiform, being broadly conical above and flattened or concave below, with a wide umbilicus extending to the nucleus of the spire, as in Solarium. The aperture is very oblique, and the periphery of the volutions is extended in form of a thin flange, under which the succeeding volution is formed. No apertural slit exists, nor are the striae of growth interrupted at the periphery, except when the expansion is broken off. The surface ornamentation consists of simple lines of growth above, while below the flattened surface is marked by revolving lines. For this and similar species I propose the generic name *Eotrochus*.

## EOTROCHUS [Whitfield].

Shell conical above, flat or concave beneath and broadly and deeply umbilicated. Aperture very oblique, and the outer angle of volutions strongly carinated or expanded. Surface ornamentation unlike on the upper and lower surfaces. Type E. *CONCAVA* *Pleurotomaria concava*, Hall.

The genus differs from the umbilicated forms of the Trochidae in not having the inner or umbilical surface of the volution distinct from the basal parts (i. e., not forming a columella), but the lower or basal surface of the volution slopes gradually and smoothly into, and forms the sides of the umbilicus, giving an obliquely elliptical section to the volution. From the forms usually placed under *Onustus*, Humph., it differs but little except in the character of growth and surface of the lower side of the volutions. So far as known, it forms no peripheral digitations or ornamentation as in that genus. In the Pal. Rept. of Ohio, Vol. I, p. 221, Mr. F. B. Meek proposes the name *Pseudophorus* for a group of shells which he referred with doubt to *Xenophora*, Fischer, but which he does not characterize. The shell for which he proposed it, however, differs widely in character from the one under consideration; it being imperforate, although having a broad umbilical depression, and the lower surface of the shell is a direct continuation of the upper surface like the volution of *Platystoma* or *Natica*, only being angulated on the periphery, while this one possesses a distinct system of growth and surface markings. This with the open umbilicus is sufficient to distinguish it as a separate generic group, the Ohio shell being only a flattened *Platystoma*.

## EOTROCHUS CONCAVUS (Hall).

Plate XXVI, figs. 21-23.

*Pleurotomaria concava* Hall, Trans. Alb. Inst., Vol. 4, p. 24;  
*P. tenuimarginata*, Hall; Cat. Am. Pal. Foss., S. A. Miller,  
 p. 245.

"Shell trochiform; spire depressed-conical; volutions about five, flattened or slightly concave above; base of shell concave; periphery alate, alation curving downwards at the margin; aperture transversely ovate (the wider part at the pillar); umbilicus medium size, round; suture linear, rather indistinct; surface smooth

or marked by obsolescent striae, which turn abruptly backwards from the suture to the periphery; similar striae are sometimes visible on the base of the shell, bending abruptly backward on the alation.

"Diameter .25 to .75 of an inch, height from .20 to near .50 of an inch."

The original specimens of this species were so very poor that they seem to have led to some misconceptions of characters. On clearing away the rock from the base of some of the larger specimens the surface of this part is seen to be marked by about thirteen flattened revolving lines, and with the strongest hand glass no oblique lines resembling those on the upper surface can be seen, although the apparent receding of the lower lip of the aperture would give this direction. The "pillar" spoken of in describing the form of aperture should not be interpreted as indicating a solid columella, but only the wall of the open umbilicus. The largest specimen in the collection has a diameter of considerably more than one inch.

Localities.—Spergen Hill, Ind., and Alton, Ill. No individual from Bloomington is present in the collection. [Paynter's Hill and Stinesville, Ind.]

Genus PLEUROTOMARIA,\* D. France.

PLEUROTOMARIA SUBGLOBOSA Hall.

Plate XXVI, fig. 10.

Cat. Am. Pal. Foss., S. A. Miller, p. 245. *P. rotundata* Hall, Trans. Alb. Inst., Vol. 4, p. 23.

"Shell sub-globose; volutions above five or six, convex, the last one very rotund or ventricose; suture distinctly marked, and the volution depressed just below it, and rising in an obtuse, undefined angle, below which is a distinct depressed revolving line, and below this again a similar sub-angular elevation, which forms the upper limit of the broad periphery of the outer volution, thus making the upper side of the volution obscurely biangular with one depression between the angles and the other towards the suture.

\*None of the species described herein under the genus, *Pleurotomaria*, belong to that genus in the restricted sense. The time at the writer's disposal has not made it possible to give the species the necessary revision for final generic reference.—E. R. C.

These angles and the depression between are distinctly visible in the cast. Aperture broadly ovate; umbilicus small; surface marked by fine, closely arranged revolving striae.

"Diameter .09 to .45, height .04 to .38 of an inch."

On the larger individuals of this species the volutions are entirely round above and on the sides, completely destroying the subangulations spoken of in the description, the depressed band being most distinct in the small and medium-sized individuals. But the term "biangular" is, perhaps, too marked to apply to so round and globular a shell. The umbilicus is very distinct when clear of adhering rock, and its margin abrupt. On very well preserved specimens the under side is seen to be marked by very fine revolving lines, but those on the upper side of the volutions only are visible on most examples.

Localities.—Spergen Hill and Bloomington, Ind., and Alton, Ill. [Harrodsburg, Ellettsville, Stinesville and Romona, Ind.]

#### PLEUROTOMARIA SWALLOWANA Hall.

Plate XXVI, figs. 1 and 2.

Trans. Alb. Inst., Vol. 4, p. 24.

"Shell depressed, somewhat globose, spire little elevated; volutions about five, regularly rounded, the last one sub-ventricose, and sometimes a little more expanded at the periphery; suture well defined; aperture sub-circular, a little oblique on the pillar; umbilicus large, circular; a flattened band upon the periphery of the shell margined on each side by a distinct elevated line; volutions crossed by fine, even, thread-like striae, which are smaller than the spaces between them, more conspicuous on the upper side of the volutions and often obsolete on the lower side.

"Diameter .12 to .25, height .07 to .20 of an inch."

The general resemblance of this species is somewhat similar to that of *P. subglobosa*, but it is much more depressed, although very variable in this respect. The transverse striae on the upper surface of the volution, and the situation of the band which is on the periphery in this case, will serve to distinguish this species.

Localities.—Spergen Hill and Bloomington, Ind. [Also Paynters Hill, Ellettsville and Stinesville, Ind.]

## PLEUROTOMARIA TRILINEATA Hall.

Plate XXVI, fig. 20.

Trans. Alb. Inst., Vol. 4, p. 25.

"Shell ovate-conical; spire more or less elevated, acute at the apex; volutions about six, convex, last volution ventricose; suture distinctly defined; aperture sub-circular; columella perforate by a small umbilicus; surface marked upon the periphery by a comparatively broad spiral band, which is margined on each side by a linear groove; two other similar grooves between the band and the umbilicus, dividing the base of the shell into three spaces, each one equaling in width the spiral band; entire surface, except the spiral band, ornamented by revolving, thread-like striae, which are crossed by fine lines of growth, the latter becoming stronger and curving slightly backward upon the spiral band; an almost imperceptible angulation just below the umbilicus.

"Length .125 to .50 of an inch."

The measurement ".125" as given in the original paper is probably a misprint and should be .25. The largest specimen which I have observed is about .75 of an inch high.

Localities.—Spergen Hill and Bloomington, Ind., and Alton, Ill. [Harrodsburg, Ellettsville, Stinesville and Romona, Ind.]

## PLEUROTOMARIA NODULOSTRIATA Hall.

Plate XXVI, fig. 5.

Trans. Alb. Inst., Vol. 4, p. 21.

"Shell turbate; spire depressed-conical, obtuse at the apex; volutions about four, rounded, somewhat depressed above, the last one ventricose below; suture distinct, rather sharply defined; aperture sub-circular, slightly flattened on the inner side; umbilicus rudimentary; surface marked by strong, revolving elevated striae, which are about equal to the spaces between them, excepting on the periphery of the outer volution, where two or three are more distant, leaving a double spiral band; revolving striae crossed by oblique striae (parallel to the lines of growth), which are very conspicuous on the upper side of the volution, but become obsolete below the band. The revolving lines at the junction of the oblique striae become nodulose on the upper half of the volution, and particularly near the suture.

"Diameter .12 to .18, height .10 to .18 of an inch."



In most of the specimens, especially the larger ones, the upper side of the volution is obliquely flattened in the direction of the apical angle, and the periphery vertically flattened. They vary greatly in the rate of increase, the apical angle varying from less than 60 to about 90 degrees in different specimens. There are apparently two strong varieties included among those referred to the species, one having coarse revolving lines on the lower side, the other marked by very fine lines, the latter having a very depressed spire and flattened periphery, though I think there are intermediate forms enough to unite them.

Localities.—Spergen Hill and Bloomington, Ind., and Alton, Ill. [Harrodsburg, Ellettsville and Stinesville, Ind.]

PLEUROTOMARIA WORTHENI Hall.

Plate XXVI, fig. 4.

Trans. Alb. Inst., Vol. 4, p. 23; Geol. Rept. Iowa, 1858, p. 530, pl. 23, fig. 13.

"Shell depressed sub-globose; spire but little elevated, oblique from the great expansion of the last volution; volutions about three, somewhat flattened above, rapidly expanding, so that the last volution makes nearly the whole bulk of the shell; obtusely angulate on the periphery; upper margin of the volutions marked by a row of strong nodes, which extend about one-third across; surface marked above by striae parallel to the lines of growth, which on the last volution disappear in passing over the angulate periphery; base of last volution marked by strong revolving lines on the space between the outer margin and the umbilical area; base deeply excavated about the umbilical region, but the umbilicus is unknown. Aperture sub-quadrate, upper edge of the outer lip projecting far over the lower.

"Diameter .60, height .48 of an inch."

This shell is not a very characteristic form of *Pleurotomaria*. In fact, it approaches much nearer to the genus *Cryptaenia*, Deslonch, Mem. Soc. Lin., Vol. VIII, p. 147, than to the true *Pleurotomaria*, as the slit in the periphery has been very obscure and concealed by the succeeding volutions. The form is also depressed and the aperture very oblique, receding very much on the lower side. I have not been able to ascertain the form of the umbilicus in *Cryptaenia*, but in this species the depression is very broad

and patulose, although the real perforation itself is very small indeed. The row of nodes mentioned in the description as characterizing the upper side of the volution, have the form of undulations of this part of the shell, are somewhat oblique and only pertain to the last one or one and a half volutions. The surface of the shell when not worn is covered by revolving lines both above and below, except within the umbilical depression, the very margin of this only being marked.

Localities.—Spergen Hill and Bloomington, Ind.

#### PLEUROTOMARIA HUMILIS Hall.

Plate XXVI, fig. 3.

Trans. Alb. Inst., Vol. 4, p. 21.

"Shell depressed, trochiform, oblique, spire little elevated, consisting of three or four volutions, which increase rapidly in size from the apex; volutions depressed-convex above, and declining to the periphery; base of the last volution less convex than on the upper side, sub-obtusely angular on the periphery, which is marked by a narrow groove, little wider than the usual spaces between the revolving striae; surface marked by revolving and transverse striae, which are stronger and more distant on the upper side of the volution, giving it a beautiful cancellated appearance, while they are closer and finer on the lower side of the shell; mouth transversely oval; umbilicus small.

"Diameter .10 to .19, height .07 to .14 of an inch."

The specimens upon which this species was founded, and of which the above is the description, are only the young shells of *Pleurotomaria Wortheni* Hall, and their locality the same as that species.

[Additional material from other localities makes it certain that *P. humilis* and *P. wortheni* are one species.]

#### PLEUROTOMARIA MEEKANA Hall.

Plate XXVI, figs. 8 and 9.

Trans. Alb. Inst., Vol. 4, p. 22.

"Shell depressed-conical; spire short, rapidly diminishing and obtuse at the apex; volutions about five, appressed above and sub-angular below, with the periphery vertical; suture distinct; last

volution large, not ventricose, biangular on the periphery, with a defined groove in the center which is distinctly margined above and below by an elevated line; surface on the upper side of the volutions marked by revolving and transverse striae of equal strength, which are regularly cancellated (and when not worn there is a slight nodosity at the crossing). The revolving lines on the base of the last volution are closer and finer than those above, and equally but less distinctly crossed by the transverse lines, which make a deep sinuosity on the periphery of the shell. Aperture sub-quadrate, with a deep notch in the outer margin at the termination of the revolving band; umbilicus of medium size.

"Diameter .18, height .13 of an inch."

The species is represented in the collection by only a single imperfect specimen, on which the characters are rather obscure. It has more the form of a *Trochonema* than of a *Pleurotomaria* in the general form of the shell and spire. There is but very indistinct evidence of the "deep notch" in the outer margin of the shell, and I can not detect any revolving lines on the lower side of the last volution as stated.

Locality.—In the original paper the locality is given as Spergen Hill, but the card is marked Alton, and the specimen shows the lithological characters of the rock from that locality. Therefore I think it probable the locality has been wrongly stated by mistake.

[The Indiana University collections contain a considerable number of specimens of this species from Stinesville, Ellettsville and Harrodsburg, Ind.]

#### PLEUROTOMARIA PIASAENSIS Hall.

Plate XXVI, figs. 6 and 7.

Trans. Alb. Inst., Vol. 4, p. 22.

"Shell depressed, sub-globose; spire short and little elevated, consisting of about four volutions; volutions rapidly increasing in size, depressed-convex above, somewhat rounded below, and becoming sub-angular near the aperture; the periphery abruptly rounded and marked by a spiral groove or band; surface marked by about four strong spiral or revolving striae on the upper side of the volution, between the periphery and suture, and four or five similar

striae on the lower side; transverse striae scarcely distinct except in the spaces between the revolving striae; umbilical depression rather broad, and margined by a strong angular elevation towards the aperture of the shell; aperture sub-quadrangular, the pillar side shorter; the outer side, from the periphery to the angle bordering the umbilical region, nearly straight, and equal to the space from the periphery to the suture.

"Diameter .17, height .10 to .11 of an inch."

The shells of this species are very variable in the form of the volutions, some being round on the periphery and others quite angular, that figured being of the latter group. Of course this sharpness on the edge gives a more obliquely flattened form to the upper and lower surface, destroying to a considerable extent the "sub-globose" form as mentioned in the original description. The number of bands and the strength of the transverse striae also vary. On the angular specimens there is often a carinated band forming the margin, when it becomes difficult to distinguish the position of the slit which should characterize the genus to which it is referred.

Locality.—Piasa Creek, above Alton, Ill., the locality of the Alton bed. [Paynters Hill, Ellettsville and Stinesville, Ind.]

#### PLEUROTOMARIA CONULA Hall.

Plate XXVI, fig. 17.

*Pleurotamria* (*Murchisonia*?) *Conula*, Hall; Trans. Alb. Inst., Vol. 4, p. 26.

"Shell conical, spire gradually and uniformly diminishing from the base; volutions six to eight, angular in the middle and flattened above and below; sutures defined; surface marked by distinct, elevated, nearly vertical striae, both above and below the spiral band; spiral band occupying the periphery of the volution, and composed of three revolving minute carinations with narrow depressions between (sometimes only two elevated bands are visible); aperture sub-quadrate; columella extended below, perforate.

"Length from .08 to .18 of an inch."

The generic relations of this shell are rather obscure, as it seems to be intermediate between *Murchisonia* and *Pleurotomaria*. If it were not perforated it would form a very good *Murchisonia*.

but the type of that genus has a solid axis, and all true species of the genus in the Devonian have, while this species is very distinctly umbilicated. The slit in the aperture is very narrow, and in the specimen figured is seen to be open for nearly an entire volution, becoming gradually narrower as it recedes from the aperture, and in closing finally forms the third carination of the band mentioned in the description.

Locality.—Spergen Hill, Ind. [Also Paynters Hill, Romona, Stinesville, Ellettsville and Harrodsburg, Ind.]

[BEMBEXIA ELEGANTULA (Hall) Ulrich.\*]

Plate XXVI, fig. 19.

*Pleurotomaria elegantula*, Hall sp. [Whitfield]; *Murchisonia elegantula*, Hall; Trans. Alb. Inst., Vol. 4, p. 27; *Pleurotomaria Shumardi*, M. and W., Geol. Surv. Ill., Vol. 2, p. 260, pl. 18, fig. 6.

As the original description of this species was taken from a very imperfect and immature specimen, it is very incomplete, and I have thought best to substitute that given by Messrs. Meek and Worthen, *loc cit.*, which is much better. The shell is very good *Pleurotomaria*, and does not in its complete form possess the features of the genus *Murchisonia*.

"Shell trochiform, of medium size, very thin; spire moderately elevated, conical, somewhat attenuate at the apex. Volutions about seven, increasing rather rapidly in size, obliquely flattened above; those of the spire somewhat angular near the lower side; last one very prominent and angular around the middle, moderately convex below, the immediate edge of the angle being truncated by the narrow spiral band. Band flat or slightly concave, and margined above and below by a small, smooth, slightly elevated line; passing around a little above the suture on the whorls of the spire. Suture well defined; umbilicus small; aperture rhombic-subquadrate, wider than high. Surface ornamented by numerous transverse lines, which are very regular and closely ar-

[\*In his remarks on the family *Pleurotomariidae* Mr. E. O. Ulrich (Geol. Minn., Vol. III, Pt. II, 1892-1896, pp. 946-969) has subdivided the genus into a number of subordinate groups or genera, and refers to certain of these genera, a number of species occurring in the present fauna. Those interested in the present status of the *Pleurotomariidae* should consult the works of Koken, Burkhardt, and Ulrich.]

ranged on the upper whorls, but become stronger, more distant and less regular on the last turn. In crossing the upper, flattened, sloping sides of the whorls, these lines arch a little forward and pass very obliquely backwards from the suture to the band; on the under side of the body whorl they are smaller, or nearly obsolete, and crossed by obscure traces of fine revolving striae. Length 0.70 inch, breadth 0.73 inch; apical angle rather distinctly concave; divergence 0.70."

Localities.—Bloomington, Ind., and Warsaw, Ill. [Stinesville, Ind.]

Genus MURCHISONIA. D'Arch. and Vern.

MURCHISONIA INSCULPTA Hall.

Plate XXVI, fig. 18.

Trans. Alb. Inst., Vol. 4, p. 26.

"Shell subulate-conical; spire somewhat rapidly ascending, acute; volutions six or seven, convex and rounded in the middle, appressed and sloping gradually above, and abruptly below, to the suture; upper side of volutions marked by vertical elongate nodes, which are pointed above and gradually disappear in the surface below, or subdivide into distinct elevated striae; spiral band rather broad; margined by two distinct elevated lines, with the intermediate space convex or concave; last volution ventricose, extended below and marked by an elevated line which is a continuation of the suture line; aperture somewhat rounded and extended in front; columella extended below and imperforate.

"Length from .05 to .25 of an inch."

The species approaches more nearly to *Pleurotomaria conula* than to any other associated species, but can be readily distinguished by the more highly conical form, coarser markings, more extended aperture, more ventricose last volution, which is longer on the lower side, and by not being umbilicated. The slit in the last volution extends from the margin of the aperture backwards for about one-fourth to one-third of a volution.

Localities.—Spargen Hill and Bloomington, Ind. [Harrodsburg, Ellettsville, Stinesville and Romona, Ind.]

## MURCHISONIA TEREBRIFORMIS Hall.

Plate XXVI, figs. 15 and 16.

Trans. Alb. Inst., Vol. 4, p. 28.

"Shell extremely elongate, sublate-acute; volutions eight or nine, very convex, marked by a broad spiral band in the center, last volution ventricose; suture deeply marked; surface ornamented on the upper side of the volutions by fine striae, which extend obliquely backwards to the spiral band, below the band by one or two spiral elevated striae, and on the last volution by four or five similar striae; aperture unknown; umbilicus none.

"Length .33 of an inch."

This shell resembles in its general features *Pleurotomaria trilineata*, Hall, herein described, but is more elevated than the most slender forms of that species, and has a less ventricose volution as well as a greater number of whorls. The surface ornamentation is quite distinct, as there are none of the fine revolving lines above the band on this one, the surface being marked by transverse striae only, and the revolving lines below are raised, flattened, narrow bands instead of impressed lines, as on that one. The shell is also imperforate.

Locality.—Bloomington, Ind. [Harrodsburg, Ellettsville, Stinesville and Romona, Ind.]

## [SOLENOSPIRA VERMICULA (Hall) Ulrich.]

Plate XXVI, fig. 11.

*Murchisonia vermicula*, Hall [Whitfield]; Trans. Alb. Inst., Vol. 4, p. 27.

"Shell cylindrical, abruptly tapering at the apex; volutions from six to ten, moderately convex in the middle and scarcely diminishing for the first four or five turns above the base, but becoming more abruptly contracted above; surface of each volution marked by two very prominent revolving striae, having a space between them on the periphery, and a single finer line below and one above near the suture; the last volution not ventricose, and marked by a fifth revolving striation, which is a continuation of the suture line; aperture broadly oval, rounded below; columella imperforate. Shell minute.

"Length .14 of an inch."

This is the smallest gasteropod found in the Spergen Hill beds, and is extremely abundant in certain layers. The shell is nearly cylindrical for more than half its length in the larger specimens, the increase being mostly in the upper four or five volutions. The spiral bands are often nearly obsolete, or the upper and lower are indistinct, and the central ones very strongly marked. It is readily distinguished from the apical portion of *M. turritella* by its cylindrical form, that one being regularly tapering. [Ulrich, *loc. cit.*, refers this form to the genus *Solenospira*.]

Localities.—Spergen Hill and Bloomington, Ind. [Paynters Hill, Harrodsburg, Bloomington, Ellettsville, Stinesville and Romona, Ind., abundant.]

[SOLENOSPIRA TURRITELLA (Hall) Ulrich.]

Plate XXVI, fig. 12.

*Murchisonia turritella*, Hall [Whitfield]; Trans. Alb. Inst., Vol. 4, p. 27.

"Shell subulate, elongate, gradually tapering to the apex; suture distinct; volutions about nine; equally rounded, the last one slightly ventricose; surface marked by closely arranged, rounded, revolving striae, which are stronger on the middle of the volution; five revolving striae on each volution of the spire, and about seven on the last volution; aperture sub-ovate; columella slightly extended and curved around the aperture, imperforate.

"Length .18 to .50 of an inch."

The shells of this species are very variable in their rate of increase and in the comparative height of the volutions, as also in the strength of the revolving lines. These latter are often quite sharp or angular, or others are rounded as stated in the description above. The band marking the slit in the lip is situated above the middle of the volution, and is not well marked until the shell attains considerable size, when it becomes distinct. This feature gives a central or sub-central line, so that there are five lines exposed on each volution. There is but one associated species with which it will be readily confounded, namely, *M. attenuata*, under which species comparisons will be found. [Ulrich, *loc. cit.*, refers this species to the genus *Solenospira*.]

Locality.—Spergen Hill, Ind. [Paynters Hill, Harrodsburg, Bloomington, Big Creek (Stinesville) and Romona, Ind.]



## [SOLENOSPIRA ATTENUATA (Hall) Ulrich.]

Plate XXVI, fig. 13.

*Murchisonia attenuata*, Hall [Whitfield]; Trans. Alb. Inst., Vol. 4, p. 27.

"Shell subulate, elongate; spire very gradually tapering; volutions nine or more, flattened, scarcely convex in the middle, and marked by a spiral band which is margined on either side by a strong elevated line; suture bounded on each side by a sharp elevated line which is smaller than those bordering the spiral band; aperture transverse; umbilicus none."

There will always be considerable difficulty in distinguishing between this one and *M. turritella*, more especially so as no perfect specimens of this have been observed, so that the entire characters are unknown. It is probably a distinct species, but the only distinction that remains constant, even among the small number of individuals observed (some five), consists of the number of revolving lines, which on this one is four, and on that five. As a pretty general thing they are sharper on this form, and those near the suture line less distinctly so than those bordering the band. This feature destroys that roundness of the volutions so characteristic of *M. turritella*. The band is also situated near the middle of the volution, and the shell is perhaps a little more slender. [Ulrich, *loc. cit.*, refers this species to the genus *Solenospira*.]

Locality.—Spergen Hill, Ind. [Paynter's Hill, Harrodsburg, Bloomington, Ellettsville, Stinesville and Romona, Ind.]

The Indiana University collection contains a considerable number of specimens of this species. It is probably distinct from *S. turritella*.]

## MURCHISONIA VINCTA (Hall).

Plate XXVI, fig. 14.

*Loxonema vincta*, Hall; Trans. Alb. Inst., Vol. 4, p. 28.

"Shell extremely elongate, very gradually tapering from the base; volutions convex below, appressed above, banded just below the suture and marked by transverse arching striae; aperture ovate, wider below; umbilicus none.

"Length 1 inch."

The description given of this species is very incomplete, and the specimens are usually too imperfect to afford means for better.

The volutions have been as much as ten or twelve in number, are very little convex, the upper half being depressed from the presence of a broad concave band just above the center, which gives them an obliquely flattened character, and throws the greatest convexity below the middle, often causing a slight angularity and leaving a narrow, flattened band below the suture line above the band. This form is so common a feature of the genus *Loxonema* that it is very natural to make the wrong generic reference, especially as the surface markings are extremely fine and often obsolete. In the type specimen, however, they can be seen with a good glass and show a decided recurving in crossing the depressed band, showing decidedly its generic affinities with *Murchisonia*. It is the largest shell of the form found in these beds, and is readily distinguished from any of the non-lirated species by its more slender form, and from those by its greater size and smooth volutions.

Locality.—All the specimens yet observed have been from Spengen Hill, Ind. [Ellettsville, Stinesville and Romona, Ind.]

### HETEROPODA.\*

Genus *BELLEROPHON*, Montf.

*BELLEROPHON* *SUBLÆVIS* Hall.

Plate XXV, figs. 6 and 7.

Trans. Alb. Inst., Vol. 4, p. 32; Geol. Iowa, 1858, p. 666, pl. 23, fig. 15.

"Shell sub-globose, inflated on the last volution; aperture transverse, arcuate, expanded, the lip thickened and much extended at the junction with the volution; umbilicus none; dorsum carinated by a narrow, slightly elevated carina, surface ornamented by fine, regular striae, which bend abruptly and deeply backwards on the carina, denoting the depth of the emargination of the lip; striae sometimes irregular from interrupted growth.

"Length from .062 to .875 of an inch."

This shell belongs to the non-umbilicated section of the genus, and in the adult shell the lip is much thickened over the umbilical area, so as to form a strong callus, while in the younger stages it is

\*The genus *BELLEROPHON* is not now placed in the *HETEROPODA*, but occupies a position in the *RIPHIDOGLOSSA* near the *Pleurotomaridae*.

but slightly thickened, or in the very young is thin and scarcely enrolled. The volutions are strongly embracing, the last one so much so as to give a deeply reniform aperture. The dorsal keel is but slightly marked and very narrow, and in very many of the larger individuals becomes entirely obsolete, either from an external deposit or from a kind of erosion which has taken place before the shells were finally imbedded, and which has also obliterated the surface markings. Besides the broad emargination of the lip indicated by the transverse lines of growth, they sometimes show a deep slit of the width of the dorsal band extending an eighth of an inch or more from the margin of the lip. There is no described species from the lower Carboniferous formations that approaches very near this one. *B. Stevensianus*, McChes., Pal. Foss., pl. 2, fig. 18, from the Coal Measures of Illinois and the West, is as near as any, but is compressed laterally, more strongly marked and more distinctly carinate. Specimens measuring an inch and one-eighth have been more recently obtained at Spergen Hill and at Ellettsville, Ind.

Localities.—Spergen Hill, Bloomington, Paynter's Hill and Ellettsville, Ind., and Alton, Ill. [Also Harrodsburg and Stinesville, Ind.]

[BELLEROPHON SP?

A specimen from Spergen Hill only generically identified.]

[BELLEROPHON GIBSONI White.

Plate XXIV, figs. 5-5b.

Indiana, Dept. Geol. and Nat. Resources, Vol. II 1881, p. 360, pl. 41, figs. 4, 5 and 6.

"Shell very large for a species of this genus; whorls gradually increasing in size, broadly rounded on the outer side, especially on the outer portion of the last one; aperture large, expanding by reflexion of the lip at the sides, but apparently not so expanding in front.

"The larger examples, when perfect, had a length of at least 65 millimeters and a breadth of aperture of 50 mm."

\* \* \* \* \*

"Position and Locality.—St. Louis group of the Subcarboniferous limestone series, Greencastle, Putnam County, Indiana."

(White, *loc. cit.*) Ellettsville, Bedford and Bloomington, Indiana, in the Salem limestone.]

[*BUCANOPSIS TEXTILIS* (Hall) Ulrich.]

Plate XXV, figs 4 and 5.

*Bellerophon textilis*, Hall [Whitfield]; *Bellerophon textilis* Hall; Cat. Pal. Foss. S. A. Miller, 1877; *B. cancellatus*, Hall, Trans. Alb. Inst., Vol. 4, p. 31.

"Shell sub-globose; aperture transversely oval, arcuate, with the lip reflexed at the sides; umbilicus small in young shells and scarcely visible in the older specimens from the thickening of the lip; surface marked by fine longitudinal elevated striae, of which about thirty may be counted on each side of the carina, increasing by implantation with the age of the shell; carina rather narrow and little elevated, very indistinctly marked by the longitudinal striae. Transverse striae in the direction of the lines of growth, irregular, subimbricate, more distant than the longitudinal striae, bending backwards on the carina. At the crossing of the two sets of striae the surface is slightly nodulose in well preserved specimens.

"Length .125 to .75 of an inch or more."

This is the only cancellated form described from the Carboniferous rocks of the Western States, and is a form more characteristic of the Devonian and Waverly formations than of this horizon. The shells which I have seen all have the appearance of immaturity, and there is an uncertainty as to whether the lip may or may not have been reflected in the adult stages, like those of the same type in the lower formations mentioned. If it were thin and unreflected as in the specimens known, this alone would be a distinguishing mark. But the even cancellation of the surface otherwise distinguishes it from all except *B. Leda*, Hall, from the Hamilton shales of New York, which always has a broader band, and is rather more decidedly umbilicate. [Ulrich, *loc cit.*, refers this species to the genus *Bucanopsis*.]

Localities.—Spergen Hill and Bloomington, Ind. [Also Paynter's Hill, Harrodsburg and Stinesville, Ind.]

[Genus *SUBULITES* Conrad.*SUBULITES HARRODSBURGENSIS* n. sp.

Plate XXIV, figs. 7-7b.

Shell very elongate, cigar-shaped, smooth; spire long, tapering very gradually. Volutions flat, seven or eight in number, rather oblique; last volutions scarcely larger than the one preceding. Suture scarcely visible, even in well preserved examples. In poorly preserved specimens and in all specimens except under a magnifier, the surface appears perfectly smooth, causing these shells to bear an astonishing resemblance to somewhat worn sea-urchin spines. Aperture notch-shaped, short and abruptly truncated at the bottom. Inner lip thickened. Length of average specimens from 5 to 6.5 mm., diameter 1.0 mm. to 1.5 mm.

Harrodsburg, Ind., abundant; Bloomington, Ind., rare.

Indiana University collection.]

[Genus *SOLENISCUS* M. & W.*SOLENISCUS GLABER* n. sp.

Plate XXIV, figs. 9-9a.

Shell conical smooth, spire sharp, conical and well elevated; volutions five, smooth, flat or slightly convex, last volution more convex and very large. Suture shallow, not strongly marked. Aperture elongate-oval pointed both above and below. Outer lip thin and sharply defined. Columella spirally twisted so as to give the effect of a ridge on the inner margin of the aperture. The base of the columella is channelled. Length of largest specimen 9 mm., diameter of last volution 4.5 mm. Only a few specimens of this species have been seen.

Locality.—Spergen Hill, Ind., very rare.

Indiana University collection.]

[*PLATYCERAS CIRCULARIS* Rowley sp.

Plate XXIV, figs. 11-11a.

Indiana Paleontology, VIII, Aug. 14, 1901, p. 70, pl. 23, figs. 32, 33.

"Shell ventricose. Spire slightly inrolled; the body of the shell rather rapidly expanding to the almost perfectly circular aperture. The concentric striae almost obliterated in silicification of the shell.

The circular outline of the aperture and the slightly curved spire make it easy to identify this species.

The type comes from the Warsaw [Salem] group at Lanesville, Ind., and is in the collection of G. K. Greene.]

[Genus ANOMPHALUS M. & W.

ANOMPHALUS ROTULIFORMIS n. sp.

Plate XXIV, figs. 12-12a.

Shell robust, smooth; spire depressed, scarcely rising above the level of the last volution, slopes continuous with those of the last volution, so that in profile the shell appears uniformly rounded over the apex. Whorls about three in number, inner one very small and expanding very rapidly, so that the outer whorl is much larger than the preceding one (ratio of diameters about 3 to 1). Suture very narrow, but plainly marked. The successive whorls overlap to such an extent and their profiles join each other with such an even curvature that the suture is scarcely depressed below the general level of the surface of the shell. This character distinguishes these shells at once from *Straparollus*, which they resemble in their low spires and smooth rounded whorls. Aperture round. Umbilicus shallow. This species is very similar to *A. rotulus*, M. and W., but differs somewhat in the profile of the whorls.

Locality.—Spergen Hill, Ind., rare.

Indiana University collection.]

[Genus POLYTREMARIA de Konink.

POLYTREMARIA (?) SOLITARIA n. sp.

Plate XXIV, figs. 6-6a.

A single specimen from Spergen Hill has the following characters: Shell planorbiform, smooth; spire slightly elevated above the level of the outer whorl and having a concave profile. Five volutions; the four inner ones expanding rather slowly, the outer one considerably larger than the next preceding whorl. Suture well defined. The profiles of the volutions are well rounded on the sides, somewhat flattened on top and descending into the sutures with an easy curve. Aperture not exposed. Umbilicus

broad and deep. The feature of this shell that distinguishes it from any other known to the writer from the rocks of this horizon, is the two sinuous lines alternately approaching and receding from each other and occupying the place of the slit-band of the PLEUROTOMARIIDAE. This feature at once distinguishes the shell from *Straparollus spergenensis*, which it otherwise resembles so closely as to make it likely that the species is commonly mistaken for the latter, and that this fact accounts for its not hitherto having been detected.

These sinuous lines on the middle of the whorl represent the margins of the (closed) slit, which alternately approach each other very closely, thus giving rise to a row of perforations similar to those of *Haliotis*. In *Pleurotomaria catenata*, de Konink, the only species with which I can compare this, the coalescence of the slit margins is complete, whereas in the present form they merely approach each other closely. The species is placed provisionally in the genus *Polytremaria*.

Locality.—Spergen Hill, Ind., very rare.

Indiana University collection.]

[Genus GRYPHOCHITON Gray.

GRYPHOCHITON (?) PARVUS (Stevens).

Plate XXIV, figs. 8-8c.

*Chiton parvus* Stevens, Am. Jour. Sci. (2), Vol. 25, p. 264.

"Anterior valve semi-circular, conical. Apex pointing posteriorly, sloping regularly to the margin. Middle valves acutely sub-rhomboidal, scooped in front, sharp behind, dorsum elevated, terminating posteriorly in an acute apex. Posterior valve semi-circular behind, abrupt in front, rising into an acute ridge, extending to the middle of the valve, terminating in an acute apex, from which the valve slopes to the margin, which is thickened and turned up. Accessory plates are more broadly rounded than in the preceding species [*Chiton carbonarius*]. Surface under glass minutely granulated.

"Length.—Plates 0.1 of an inch, shell 1 to 2 inches."

The locality given by Stevens is "Bergen Hill," Indiana, in the "Archimedes limestone." This must certainly mean Spergen Hill. The above description applies very well to specimens in the

Indiana University collection from the Salem limestone at Harrodsburg, Ind. At the latter locality the species is not uncommon. It is also present at Bloomington, Ellettsville, Stinesville and Romona, Ind.]

[Genus *ACMAEA* Eschscholtz.

Plate XXIV, figs. 6-6a.

The specimens figured are doubtfully referred to this genus.]

## PTEROPODA.

Genus *CONULARIA*, Miller.

*CONULARIA SUBLATA* Hall.

Plate XXV, fig. 3.

Trans. Alb. Inst., Vol. 4, p. 32.

"Shell quadrangular, the four sides nearly flat and converging at an angle of about 18 degrees; surface marked with a distinct longitudinal groove on each of the angles, and numerous regular, smooth, closely arranged, elevated, transverse striae, which pass a little obliquely downwards towards the middle of each of the sides, where they meet at a very obtuse angle. A single sharp longitudinal line passes down the center of each side, without interrupting the transverse striae; angles truncate or rounded towards the apex.

"Length .50 of an inch."

The striae on this shell, so far as can be determined from the imperfect specimens in the collection, are smooth, and have had no longitudinal striae crossing them, cutting their surfaces into ornaments, as is generally the case in this genus. They are very angular and occupy the entire space of the furrow. The number in a given distance varies with the distance from the apex of the shell, one counting eighteen in a tenth of an inch where the shell measures a twelfth of an inch in diameter, and another where the shell is a trifle less than a sixth of an inch in diameter there are only ten in the same distance. The specimens are too small and imperfect to afford means for comparison with other described forms.

Locality.—Alton, Ill. [This species has not yet been recognized in Indiana.]



## [CONULARIA MISSOURIENSIS Swallow.

Trans. St. Louis Acad. Sci., Vol. I, p. 657.

"Shell large, in the form of an elongated four-sided pyramid with a depressed rhombic base. The obtuse lateral edges are marked by deep angular sulcations; the acute lateral edges subcarinated. Surface polished; each of the four sides marked by flexuous, high, sharp plications. There are two sets of plications on each side; they commence on the sides and curve towards the base, then partially back, when they meet or intersect in the middle, forming an indistinct longitudinal sulcation along the middle of each side; the space between the plications is at least twice as wide as the plications. There are ten plications in a space equal to the width of the side where they are situated.

"From the Carboniferous limestone of Cooper County (Missouri)," Swallow, *loc. cit.*

An example of this species in the State Museum of Indiana is labeled from Spergen Hill, but may be from a higher horizon than the Salem limestone. It resembles very closely the specimen figured by Meek and Worthen (Geol. Ill., Vol. V, pl. 22, fig. 5), but has the crenulations on the costæ mentioned by Calvin (Am. Geol., Vol. V, p. 207.)

## [CONULARIA GREENEI Miller and Gurley.

Plate XXIV, fig. 14.

Bull. No. 11, Ill. State Mus., p. 27, pl. III, fig. 3.

"Species long, slowly expanding, pyramidal, subquadrated, sides equal, deeply furrowed at the four angles. Longitudinal line in the middle of each side. Surface ornamented with wide, concave, smooth furrows that arch forward from the four angles. These furrows are separated by sharp costæ, generally without crenulations. The costæ sometimes cross the mesial line without interruption, in other cases they terminate alternately at the mesial line. They do not curve forward when bending into the furrows at the four angles, nor do they reach the bottom of the furrows. They alternate in these furrows. The transverse furrows are crossed by a few longitudinal wrinkles, at the margin of the longitudinal furrows.

"There are only thirteen transverse furrows in an inch, where our specimen is eight-tenths of an inch in diameter. The shell of our specimen is horny and has the smooth, hard appearance of the test of a trilobite.

"This species is so different from all that have heretofore been described, from the Keokuk Group, that no comparison with any of them is necessary. It is distinguished by its slender form, wide, transverse, smooth furrows and sharp costæ. There are some slight crenulations on the costæ, toward the larger end of our specimens, but none toward the smaller end." (Miller and Gurley, *loc cit.*)

Mr. G. K. Greene has submitted the specimen figured herein, and which is said to come from Spergen Hill. There is, however, some doubt both as to the horizon and locality. It is quite likely that *C. Greenei* and *C. Missouriensis* will prove to be one species.

## CEPHALOPODA.

Genus ORTHOCERAS, Breyn.

ORTHOCERAS EPIGRUS Hall.

Plate XXV, fig. 2.

Trans. Alb. Inst., Vol. 4, p. 33.

"Shell sub-cylindrical, very gradually tapering; section circular; siphuncle small, sub-central; septa slightly concave, separated by spaces equal to about one-third the diameter of the shell; surface marked by distant, rather faint, longitudinal lines."

The only specimen of the species in the collection is a fragment retaining five chambers. The septa are remarkably flat. With a strong hand glass I fail to find any indications of the "rather faint longitudinal lines" spoken of in the original description.

Locality.—Spergen Hill, Ind. [Ellettsville and Harrodsburg, Ind.]

[ORTHOCERAS SP?

Plate XXIV, figs. 13-13a.

The specimens figured are from the collection of Mr. G. K. Greene and were collected at Edwardsville, Ind.]

Genus NAUTILUS,\* Breynius.

NAUTILUS CLARKANUS Hall.

Plate XXV, fig. 1.

Trans. Alb. Inst., Vol. 4, p. 32.

"Shell sub-discoidal, flattened on the dorsum and angular at its lateral margin; umbilicus large, showing all the inner volutions; volutions (number unknown) rapidly diminishing, broader than high, not embracing; surface ornamented by a deep, revolving groove around the dorso-lateral margin, between which and the umbilicus is a single row of indistinct nodes, and about five or six strong striae, which are crossed by fine elevated striae. Aperture transversely oval; septa slightly concave, and separated by spaces about equal to one-fourth the greater diameter of the volutions.

"The specimen described is somewhat worn upon the dorsal side, which may have obliterated the fine transverse or longitudinal striae, remaining upon the lateral edge of the shell."

The specimen used for the above description is a fragment of what was a much larger shell, and from its imperfect condition has led to a misconception of the characters of the species. There are three small fragments in the collection, which show that the volutions were not flattened on the dorsum, but that portion which forms the flat surface, and the border of the "deep revolving groove around the dorso-lateral margin" of the volution is only a portion of the inner surface of a succeeding volution which has been broken away, leaving the ventral portion attached to the present one. The dorsal surface has been broadly convex, and so far as seen on the fragments mentioned has been marked by revolving ridges, coarser and more distant than on the side of the volution. None of the specimens show the position of the siphon or afford means of comparison with other species.

Locality.—Spergen Hill, Ind. [Paynters Hill.]

[\*In the restricted sense in which the genus *Nautilus* is now used, the present species should not be referred to that genus. The writer can not with the material available, determine its true generic position.]

[Genus TEMNOCHEILUS McCoy.

TEMNOCHEILUS COXANUS M. &amp; W.

Plate XVI, figs. 3, 4.

Proc. Acad. Nat. Sci., Phila., p. 50.

Some specimens from the Indiana State Museum are doubtfully referred to this species.

Locality.—Spergen Hill, Ind.

## [TRILOBITA.

Genus GRIFFITHIDES Portlock.

GRIFFITHIDES BUFO M. &amp; W.

Plate XXIV, fig. 4.

Geol. Surv. Ill., Vol. V, p. 528, pl. 19, fig. 5.

"Entire outline elliptical, the breadth being to the length as 75 to 130. Cephalic shield forming more than a semi-circle, round in front and nearly straight behind; posterior lateral angles terminating in short, abruptly pointed spines extending back to the anterior edge of the thoracic segment. Glabella rather depressed convex, wide anteriorly and narrowing posteriorly to the neck furrow, just in front of which, and connected with the palpebral lobes on each side, it has a single small, obscure lateral lobe; neck furrow broad and well defined, both across the glabella and across the posterior margins of the cheeks; neck segment rather wide, depressed below the level of the highest part of the glabella in front of it. Eyes of moderate size, reniform, nearly as prominent as the glabella, placed but little in front of the continuation of the neck furrow across the cheeks, apparently smooth, but showing when the outer crust is removed, numerous very minute lenses beneath. Cheek sloping off rather abruptly from the eyes of the thickened margin, which does not continue around the front of the glabella; facial sutures cutting the anterior margin in front of the eyes before, and a little outside of them behind. Thorax nearly twice as wide as long, distinctly trilobate; mesial lobe but moderately prominent, nearly twice as wide as either of the lateral lobes, its eight segments merely rounded, and without furrows. Lateral lobes narrow; pleurae curving moderately downwards at less than half their length out from the axial lobe, but not dis-

tinctly geniculated, each provided with a furrow extending nearly half way out. Pygidium approaching semi-circular, with the anterior lateral angles obliquely truncated; mesial lobe but slightly wider anteriorly than the lateral; segments about eleven; lateral lobes with eight or nine segments. Surface finely granular, the granules being most distinct on the glabella, and the segments of the mesial lobes of the thorax.

\* \* \* \* \*

*Locality and Position.*—Crawfordsville, Ind.; Keokuk division of the Lower Carboniferous series." (Meek and Worthen, *loc. cit.*)

[The Indiana University collections contain specimens from Harrodsburg, Bloomington, Spergen Hill and Stinesville, in the Salem limestone.]

TABLE SHOWING THE OCCURRENCE AND RELATIVE ABUNDANCE OF FOSSILS FROM VARIOUS LOCALITIES OF THE SALEM LIMESTONE.

The table is intended to represent the occurrence and relative abundance of the species of this horizon at each of the principal localities studied. Owing to necessary haste in finishing this paper for the volume in which it must appear the table is consequently incomplete, as pointed out below. The statistics are based on collections studied in the preparation of the report.

The collections were made from Paynters Hill, Spergen Hill, Harrodsburg, Bloomington, Ellettsville and Stinesville (Big Creek quarries) by shipping in large quantities of highly fossiliferous material and working it up in the laboratory. It consisted of both the solid rock and the disintegrated material. From the latter the fossils were selected by washing.

The table is probably most complete for Harrodsburg, Ellettsville and Stinesville. Only incomplete collections have been studied from Lanesville and many of the characteristic species are wanting, probably for the same reason that they are not found at Paynters Hill, as before stated, where the same conditions exist.

Large amounts of material are on hand from Spergen Hill, but only a portion of this fauna has been carefully studied, for lack of time, so that the relative abundance can not be accurately given. The characteristic fauna, as represented in Hall's original collec-

tion is present here, however, in about the same proportion as at Harrodsburg, except that the number of species is greater and the material is in a better state of preservation.

So far only collections of Brachiopoda and Bryozoa have been made from Bedford. Further collecting will probably reveal the characteristic gastropods and other forms in favorable places. At Harrodsburg the fauna is very much dwarfed. A portion of the upper part of the stratum is highly fossiliferous, with the characteristic species of gastropods, brachiopods and pelecypods, but conditions were not such as to develop the large brachiopods as at Bedford. The specimens are usually somewhat water-worn and coated with lime.

The collection from Bloomington is only moderately complete. As a rule the fossils are hard to secure from this region, few being well preserved, save in pockets and occasional bedding planes. The table is fairly complete for Stinesville and Ellettsville. At Romona, the northernmost locality studied, as stated before, there is but a limited fauna.

## EXPLANATION OF CHARACTERS USED IN THE TABLE.

rr, very rare; r, rare; c, common; a, abundant; aa, extremely abundant (600 to 10,000 specimens); + rr to c, or thereabouts. This last character is only used when the actual number of specimens in the collection has not been ascertained.

The crinoids are usually designated as very rare, as good specimens are very hard to secure. Some of the species recorded from this horizon are not found so far in the nine localities given. They are included in the table so that it will be as nearly a complete a list as practicable at present. In such cases, of course, there will be no locality indicated in the table, but it will be found in the text.

	Lanesville.	Paynter's Hill.	Spergen Hill.	Bedford.	Harrodsburg.	Bloomington.	Ellettsville.	Stinesville.	Romona.
1. Endothyra baileyi.....		a	aa		aa		c	c	r
2. Amplexus blairi.....		c	r						
3. Bordenia zaphrentiformis.....	r	c	r						
4. Ceratopora agglomerata.....	r	c	r						
5. Cyathaxonia venustum.....	a	r	r			rr			
6. Cystelasma lanesvillensis.....		r	r						
7. Cystelasma rugosum.....	c	rr	r						
8. Cystelasma septatum.....			rr						
9. Cystelasma tabulatum.....	c	?	?						
10. Enallophyllum grabaui.....	rr					rr			
11. Michilinia indianensis.....	aa	aa	c	c					
12. Monilopora beecheri.....		c	c						
13. Palaeacis cuneiformis.....	rr	aa	aa	c	a	c	c	c	
14. Syringopora monroensis.....	aa	aa	aa	c	a	c	c	c	
15. Zaphrentis casedayi.....		a	a						
16. Zaphrentis clinatus.....	c	a	a						
17. Zaphrentis compressa.....	rr								
18. Batoerinus calyculus.....	rr								
19. Batoerinus crassitestus.....	rr								
20. Batoerinus davisii.....	rr								
21. Batoerinus davisii lanesvillensis.....	rr								
22. Batoerinus davisii sculptilis.....	r	r	r						
23. Batoerinus icosadactylus.....	r	r	r						
24. Batoerinus irregularis.....	rr								
25. Batoerinus magnirostris.....									
26. Batoerinus sacculus.....									
27. Batoerinus salemensis.....									
28. Dichocrinus blatchleyi.....		r							
29. Dichocrinus oblongus.....						rr			
30. Dichocrinus sp.....		rr	r		rr				
31. Dichocrinus striatus?.....	rr	r							
32. Dizygoerinus decoris.....			rr						
33. Dizygoerinus euconus.....			rr						
34. Dizygoerinus sp.....		c	c						
35. Dizygoerinus unionensis.....	rr	?	?						
36. Dizygoerinus whitel.....	r	c	c						
37. Forbesioerinus sp.....		?	c						
38. Iethyocerinus clarkensis.....									
39. Platyerinus bonoensis.....	c	r	r						
40. Platyerinus boonvillensis.....									
41. Platyerinus sp.....									
42. Poterioerinus coryphaeus.....	rr	+	+						
43. Symbathocerinus swallowi.....	a	c	r						
44. Talarocerinus simplex.....	+	c	r			rr			
45. Talarocerinus Cf. trijugus.....	rr								
46. Pentremites conoideus.....	aa	a	a	+	a	a	a	a	r
47. Pentremites conoideus amplus.....	+								
48. Pentremites conoideus perlongus.....	+								
49. Tricoelocerinus meekiana.....	rr	rr		rr		rr			
50. Troostocerinus wortheni.....	c	c							
51. Archaeocidaris norwoodi.....	rr	rr			c				
52. Holothurian? spicules.....	rr	rr			c				
53. Ortonia blatchleyi.....				rr		rr			

	Lanesville.	Paynters Hill.	Spergen Hill.	Bedford.	Harrodsburg.	Bloomington.	Ellettsville.	Stinesville.	Romona.
54. Spirorbis annulatus.....	.....	r	c	rr	c	rr	rr	rr	r
55. Spirorbis imbricatus.....	.....	+	rr	rr	rr	rr	rr	rr	rr
56. Spirorbis nodulosus.....	.....	rr	+	rr	rr	rr	rr	rr	rr
57. Cystodyctia lineata.....	.....	c	c	a	rr	c	a	a	a
58. Cystodyctia ocellata.....	.....	c	c	a	r	c	a	a	a
59. Dichotrypa flabellum.....	.....	c	a	a	r	c	a	a	a
60. Dichotrypa sp.....	.....	c	a	a	r	c	a	a	a
61. Fenestella compressa elongata.....	.....	.....	.....	c	rr	rr	rr	rr	rr
62. Fenestella exigua.....	.....	.....	.....	c	rr	rr	rr	rr	rr
63. Fenestella multiapinosa bedfordensis.....	.....	?	?	?	rr	rr	rr	rr	rr
64. Fenestella rudis major.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
65. Fenestella serratula.....	.....	.....	.....	c	rr	rr	rr	rr	rr
66. Fenestella serratula quadrata.....	.....	.....	.....	c	rr	rr	rr	rr	rr
67. Fenestella serratula perversa.....	.....	.....	.....	c	rr	rr	rr	rr	rr
68. Fenestella tenax mumtinososa.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
69. Fenestella nodosa.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
70. Fenestella tenuissima.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
71. Fenestralia sanctiludovici.....	.....	.....	+	rr	rr	rr	rr	rr	rr
72. Fenestralia sanctiludovici compacta.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
73. Fistulipora spergenensis.....	.....	a	a	a	rr	rr	rr	rr	rr
74. Fistulipora spergenensis minor.....	.....	a	a	a	rr	rr	rr	rr	rr
75. Fistulipora sp.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
76. Glyptopora michelinia.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
77. Hemitrypa beedei.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
78. Hemitrypa plumosa.....	.....	.....	?	rr	rr	rr	rr	rr	rr
79. Hemitrypa proutana.....	.....	+	+	rr	rr	rr	rr	rr	rr
80. Hemitrypa proutana nododorsalis.....	.....	+	+	rr	rr	rr	rr	rr	rr
81. Pinnatopora? sp.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
82. Polypora biseriata.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
83. Polypora internodata.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
84. Polypora maccoyana.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
85. Polypora simulatrix.....	.....	?	?	+	c	c	c	c	c
86. Polypora spiniodata.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
87. Polypora st. lata.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
88. Rhombopora bedfordensis.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
89. Rhombopora sp.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
90. Stenopora rudis.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
91. Stenopora tuberculata.....	.....	.....	?	rr	rr	rr	rr	rr	rr
92. Stenopora sp.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
93. Worthenopora spinosa.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
94. Worthenopora spatula.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
95. Athyris densa.....	.....	c	c	c	c	c	c	c	c
96. Camarophoria subcuneata.....	.....	c	r	r	c	c	c	c	c
97. Centronella?? crassi cardinalis.....	.....	rr	rr	rr	rr	rr	rr	rr	rr
98. Cleiothyris hirsuta.....	.....	a	c	c	a	c	c	c	c
99. Dielasma formosa.....	.....	+	c	+	rr	a	+	c	c
100. Dielasma gorbui.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
101. Dielasma turgidum.....	.....	rr	c	r	c	c	rr	a	c
102. Eumetria macyi.....	.....	a	c	c	c	c	rr	a	c
103. Orthothetes minutus.....	.....	rr	r	c	r	c	+	rr	rr
104. Productus biseriatus.....	.....	.....	.....	r	c	+	c	rr	rr
105. Productus burlingtonensis? var.....	.....	.....	.....	c	c	c	c	c	c
106. Productus gallatinensis.....	.....	.....	.....	r	r	r	r	r	r
107. Productus indianensis.....	.....	r	rr	c	r	+	c	c	c
108. Pugnax grosveneri.....	.....	a	c	r	c	c	c	c	c
109. Pugnax? quadrirostris.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
110. Reticularia pseudolineata.....	.....	.....	.....	r	c	+	c	c	c
111. Reticularia setigerus.....	.....	r	c	c	rr	rr	rr	rr	rr
112. Rhipidomella dubia.....	.....	a	c	c	+	c	c	c	c
113. Rhynchonella ricinula.....	.....	.....	.....	+	c	c	c	c	c
114. Rhynchonella mutata.....	.....	.....	.....	rr	rr	rr	rr	rr	rr
115. Seminula trinuclea.....	.....	a	c	rr	r	c	rr	r	c
116. Spirifer bifurcata.....	.....	c	c	+	c	r	c	rr	rr
117. Spirifer horizontalis.....	.....	+	+	+	rr	rr	rr	rr	rr
118. Spirifer lateralis delicatus.....	.....	+	+	+	rr	rr	rr	rr	rr
119. Spirifer sp.....	.....	.....	.....	c	c	c	c	c	c
120. Spirifer subaequalis.....	.....	rr	?	rr	rr	rr	rr	rr	rr
121. Spirifer subcardiiformis.....	.....	.....	.....	r	rr	rr	rr	rr	rr
122. Spirifer suborbicularis.....	.....	rr	rr	rr	rr	rr	rr	rr	rr
123. Spiriferina norwoodana.....	.....	+	c	c	c	r	+	rr	rr
124. Conocardium carinatum.....	.....	.....	.....	+	rr	rr	rr	rr	rr



	Lanesville.	Paynters Hill.	Spergen Hill.	Bedford.	Harrodsburg.	Bloomington.	Ellettsville.	Stinesville.	Remona.
125. <i>Conocardium catastomum</i> .....			+	...	c	+	r	c	ff
126. <i>Conocardium cuneatum</i> .....			+	...	r	+	...	c	...
127. <i>Conocardium pratense</i> .....				+	ff	+	...	c	...
128. <i>Cypriocardia indianensis</i> .....	+	ff			cc	ff	c	c	c
129. <i>Edmondia? subplana</i> .....	+		+		cc	ff	+	c	...
130. <i>Goniophora? plicata</i> .....					cc	ff	+	c	...
131. <i>Macrodon sp.</i> .....			ff	...				...	...
132. <i>Microdon ellipticus</i> .....			+	...				...	...
133. <i>Microdon oblongus</i> .....		ff		+	c	ff	ff	r	ff
134. <i>Microdon subellipticus</i> .....					cc	ff	ff	r	...
135. <i>Nucula shumardana</i> .....			+	...	c	c	ff	ff	ff
136. <i>Nuculana nasuta</i> .....			+	...	ff	ff	ff	ff	ff
137. <i>Pteronites spergenensis</i> .....					ff	ff	ff	ff	ff
138. <i>Acmacea? sp.</i> .....	ff								...
139. <i>Anomphalus rotuliformis</i> .....			ff	+		+	+	...	...
140. <i>Bellerophon gibsoni</i> .....				+		+	+	...	...
141. <i>Bellerophon sp.</i> .....		ff						...	...
142. <i>Bellerophon sublaevis</i> .....			+	...	r	+	a	c	...
143. <i>Bembexia elegantula</i> .....			+	...	c	+	r	ff	...
144. <i>Bucanopsis textilis</i> .....		r		...	c	+	r	c	...
145. <i>Bulimorpha bulimiformis</i> .....		ff	+	...	c	c	c	c	ff
146. <i>Bulimorpha canaliculata</i> .....	+		+	...				ff	...
147. <i>Bulimorpha elongata</i> .....	+		+	...				ff	...
148. <i>Coeloconus sp.</i> .....			?	?	?			...	...
149. <i>Conularia greenei</i> .....			?	?	?			...	...
150. <i>Conularia missouriensis</i> .....			?	?	?			...	...
151. <i>Cyclonema leavenworthana</i> .....				+	a	a	a	aa	r
152. <i>Eotrochus concavus</i> .....			ff	+					ff
153. <i>Glyptochiton? parvus</i> .....					c	ff	ff	r	ff
154. <i>Holopoea proutana</i> .....		ff	+	...	a	a	c	a	c
155. <i>Loxonema yandallana</i> .....			+	...	r			r	r
156. <i>Macrocheilus littoraneus</i> .....				+		+		+	...
157. <i>Macrocheilus stinesvillensis</i> .....									...
158. <i>Murchisonia littorana</i> .....			+	+	a	c-a	c	a	ff
159. <i>Murchisonia sp.</i> .....			ff	...					...
160. <i>Murchisonia terebriformis</i> .....					c	+	ff	c	ff
161. <i>Murchisonia vineta</i> .....			+	...	c			c	ff
162. <i>Orthonychia acutirostre</i> .....	c	r	r	r					ff
163. <i>Pleurotomaria conula</i> .....		ff	+	...	c		r	c	r
164. <i>Pleurotomaria meekana</i> .....			?	...	ff		c	c	...
165. <i>Pleurotomaria nodulostriata</i> .....	+		+	...	ff		r	c	...
166. <i>Pleurotomaria piazzaensis</i> .....		ff		...			ff	c	...
167. <i>Pleurotomaria subglobosa</i> .....			+	...	c	r	ff	c	ff
168. <i>Pleurotomaria swallowana</i> .....		ff	+	...		ff	r	c	...
169. <i>Pleurotomaria trilineata</i> .....			+	...	ff	+	ff	r	ff
170. <i>Pleurotomaria wortheni</i> .....			+	...		ff			...
171. <i>Polytrema solitaria</i> .....			ff	...		ff			...
172. <i>Soleniscus glaber</i> .....			r	...					...
173. <i>Solenospira attenuata</i> .....		ff	+	...	c	ff	c	ff	r
174. <i>Solenospira turritella</i> .....			+	...	a	c		a	c
175. <i>Solenospira vermiculata</i> .....		ff	+	...	a	r	r	c	r
176. <i>Strophostylus carleana</i> .....			+	...	c	+	e	a	ff
177. <i>Straparollus spergenensis</i> .....	c	aa	...	aa	c	aa	aa	c	...
178. <i>Subulites harrodsburgensis</i> .....			...	aa	r			ff	...
179. <i>Nautilus clarkanus</i> .....		ff	ff	ff	ff	ff	ff	ff	...
180. <i>Orthoceras epigrus</i> .....			ff	ff	ff	ff	ff	ff	...
181. <i>Orthoceras sp.</i> .....	ff								...
182. <i>Temnocheilus sp.</i> .....			+	...					...
183. <i>Cephalopod sp. (Nautilus)</i> .....			+	...					...
184. <i>Griffithides bufo</i> .....				...	ff		ff		...
185. <i>Leperditia carbonaria</i> .....				...	c	c	c	a	c
186. <i>Leperditia sp.</i> .....				...	ff				...
187. <i>Cytherellina glandella</i> .....				...	ff		c	c	c
187. <i>Ostracod sp.</i> .....				...	ff				...

## FISH REMAINS FROM THE SALEM LIMESTONE OF INDIANA.

E. B. BRANSON.

At the request of Dr. J. W. Beede of the Indiana Geological Survey the writer has prepared this report on the fish remains from the Salem limestone. The material at the writer's disposal was a collection belonging to Mr. G. K. Greene, a few specimens from the American Museum of Natural History, a small collection belonging to the University of Indiana, and several specimens from Walker Museum, University of Chicago. The writer is under obligations to Dr. Stuart Weller for the use of the collection from Walker Museum.

CLADODUS FEROX Newberry and Worthen.

Plate XLI, Figs. 3 and 4.

*Cladodus ferox* Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 26, pl. 1, fig. 11.

Teeth of large size, breadth greater than height; base semi-elliptical, with a shallow sinus in front, smooth throughout; median cone slightly curved backward, conical with a circular section, finely and evenly striated longitudinally; lateral denticles about five on either side; exterior pair one-third the height of the principal cone, conical, acute, striated throughout, divergent from median cone and strongly curved backward; intermediate denticles about four on either side, largest half the size of the exterior pair, conical, striated, projecting forward.

The teeth of this species vary considerably. The base varies from about twice as long as broad to about two and one-half times as long as broad; the central cone sometimes occupies two-sevenths the space of the anterior part of the base and sometimes not more than one-fifth. Besides the five main denticles on either side, there are four or five minute denticles located between the anterior edges of the others or on the antero-lateral part of their bases. The outermost is the largest of the lateral denticles, the third next largest.

It seems probable that the teeth named *C. stenopus* Newberry and Worthen belong to this species. Both species were described from imperfect teeth and the writer has studied several teeth from Lanesville, Indiana, that may be referred to either species with equal correctness.

CLADODUS SPINOSUS Newberry and Worthen.

Plate XLI, Figs. 1-2.

*Cladodus spinosus* Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 22, pl. 1, fig. 3.

Teeth of medium or large size, broader than high; base representing a little more than half of an imperfect hexagon, with the posterior side slightly longer than the others; thick, with a sharpish edge behind, before strong beveled under and scooped out in a shallow sinus beneath the median cone; whole anterior border of base, above the smooth beveled edge, set with many minute spines directed upward; these spines cover the anterior bases of all the lateral denticles, and the antero-lateral edges of the base of the principal cone. Median cone conical, somewhat curved backward, rapidly tapering to an acute point; lower portion with a nearly circular section, finely and evenly striated longitudinally, near the point smooth, compressed, with cutting edges; lateral denticles 6-7 on either side, conical, striated and curved backward, exterior pair much larger than intermediate ones.

Formation and Locality.—Salem limestone, Salem, Indiana; St. Louis limestone, St. Louis, Missouri.

CLADODUS INDIANENSIS sp. nov.

Plate XLII, Figs. 5-8.

Teeth small to medium size. Base almost straight in front, rounded at the ends, gently convex behind; inferior surface smooth, slightly concave in middle; superior surface flat in a narrow area behind the median cone, thence convex to the edges. Median cone low, large, subcircular in transverse section near the base, lateral cones one on each side, very close to the median but much smaller; a small denticle at the angle where the lateral and median cones meet; cones without markings of any kind save weak costae at the antero-lateral angles of the main cone.

Formation and Locality.—Salem limestone, Paynter's Hill and Lanesville, Indiana.

## CLADODUS STRIATUS sp. nov.

Plate XLII, Figs. 1-4.

Teeth of medium size, base of type specimen 14 mm. wide by about 5 mm. long, tooth broader than high. Outline of base sub-elliptical, extremities subangular, posterior border with stronger convexity than anterior; under surface smooth, upper surface with a narrow furrow just behind the cones running parallel with the posterior margin of base, a strong ridge between this furrow and the posterior margin. Middle cone low, broad and thin near base, twice as broad as thick, with sharp cutting edges; outer lateral denticles broad, thin and very low, one-third to one-fourth height of median cone; between lateral denticles and median cone a high narrow ridge that bears two-minute denticles on one side of the median cone but none on the other side in the type specimen; median cone and lateral denticles all marked with almost vertical, narrow, sharp-crested ridges, spaces between ridges about twice as broad as ridges.

*C. striatus* differs from *C. euglyphaeus*, the nearest allied species, in its much larger size, much greater breadth of median cone, greater breadth and less height of outer lateral denticles, smaller number of lateral denticles, high ridge between outer denticles and main cone, and in the greater approximation of the ridges on the teeth.

Formation and Locality.—Salem limestone, Paynter's Hill, Ind.

Type specimen No. 7709-1 American Museum of Natural History.

## CLADODUS LAMNOIDES Newberry and Worthen.

Plate XLII, Figs. 9 and 10.

*Cladodus lamnoides* Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 30, pl. 1, fig. 16.

Teeth small, base narrow, straight before, arched behind, relatively thin, smooth; median cone narrow, conical, recurved, slightly rounded before, strongly so behind, very acute at point, with cutting edges that extend to near the base; anterior surface smooth; posterior face finely striated longitudinally; lateral denticles two or four, outer one one-fourth the length of the principal cone.

Formation and Locality.—Salem limestone, Edwardsville, Floyd County, Indiana; Keokuk limestone, Warsaw and Nauvoo, Illinois. Trautschold reports this species from Russia.

CLADODUS sp. undescribed.

Plate XLII, Fig. 11.

A fragment of tooth of *Cladodus* from Lanesville represents an undescribed species, but is too imperfect for specific description. It differs from *Cladodus ferox* in the greater breadth of the central cone, in the large size of the outer lateral denticles, in having only three lateral denticles, in the shortness of the base on either side of the median cone, in the thickness of the base and in the presence of prominent bosses on the anterior edge of the base below the space between the median cone and outer denticles.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

PETALODUS LINGUIFER Newberry and Worthen.

Plate XLI, Figs. 13-15.

*Petalodus linguifer* Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 37, pl. 2, figs. 4-5.

Teeth large, broader than high; crown three times as broad as high, cutting edge broadly and nearly evenly arched, finely crenulated, anterior surface highly polished, root smooth, tongue-shaped, rounded below, posterior face equal in height to posterior face of crown, anterior face one-third the higher.

Formation and Locality.—Salem limestone, Edwardsville, Salem, Paynter's Hill and Lanesville, Indiana; Chester limestone, Chester and Pope County, Illinois, and Missouri.

CHOMATODUS PARALLELUS St. John and Worthen.

*Chomatodus parallelus*, St. John and Worthen, 1875, Paleontology of Illinois, Vol. 6, p. 358, pl. 10, figs. 3-4.

Teeth of medium or small size laterally elongated, with the upper and lower margins subparallel. Crown symmetrical, more or less compressed and sharp-crested, rounded at the extremities. The convex face equals in elevation half the entire height of the tooth, plane or slightly arched vertically, nearly straight laterally,

with a narrow coronal belt consisting of two or three imbrications. The concave face is occupied by a rather deep lateral depression, and bordered by three or four well-marked imbricating folds, which are gently curved upward at the extremities where they are confluent with the folds of the opposite face. The crest and basal margins are for the greater extent horizontal and parallel and in the perfect condition the crown is enveloped in a coating of enamel, which is usually more or less distinctly striated vertically. In worn specimens the crest is denticulate, due to its porous character. The base is thick and strong, nearly perpendicular to the crown, inferior surface relatively wide and obliquely beveled from the concave side to the opposite margin, the convex face nearly plane and vertically furrowed, the shallower concave face deeply channeled beneath the produced coronal margin. Length of tooth about 16 mm., height 5 mm.

In a specimen from Lanesville the crown gradually decreases in height from one end to the other, so that the height of the entire tooth is five millimeters at one end, a little more than four at the other.

Formation and Locality.—Salem limestone, Lanesville, Indiana; Warsaw limestone, Missouri and Illinois.

CHOMATODUS INCONSTANS St. John and Worthen.

Plate XLI, Figs. 29-31.

*Chomatodus inconstans* St. John and Worthen, 1875, Pal. Ill., Vol. 6, p. 360, pl. 10, figs. 5-14.

*Chomatodus varsouvinensis* St. John and Worthen, 1875, Ibid., p. 363, pl. 10, figs. 1-4.

*Chomatodus chesterensis* St. John and Worthen, Ibid., p. 363, pl. 10, figs. 15-17.

The teeth of this species vary greatly. The largest specimen examined during the present investigation is 22 mm. long, 12 mm. wide and 10 mm. high, while the smallest is 10 mm. long and 5 mm. wide at the widest part. In some of the teeth the longer sides are nearly parallel, while in others the broader end is more than twice as wide as the narrower. In some specimens the central ridge of the crown is high at one end and decreases in height until it is low at the other, while in other specimens the ridge

is nearly the same height the entire length of the tooth. The root of some of the teeth is nearly vertical, while in others it is oblique.

Formation and Locality.—Salem limestone, Lanesville and Paynter's Hill, Indiana, Illinois and Missouri; Chester group, Illinois, and Keokuk group, Iowa.

CHOMATODUS LANESVILLENSIS sp. nov.

Plate XLII, Figs. 15-18.

Type a single imperfect tooth. Tooth of medium size; crown low, convex side narrow, marked by two or three narrow ridges running parallel to the rounded edge. Concave surface pointed at one extremity, broadening rapidly until nearly twice as wide as convex surface, marked by oblique imbricating ridges, edge acute. Root narrow, short, sides parallel for about half the length, thence strongly imbeveled from concave side, rounded inward from convex side to form acute lower edge.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

HELODUS LAEVIS Newberry.

Plate XLI, Figs. 16-22.

*Helodus laevis* Newberry, 1879, Geological Survey of Indiana, p. 343.

Teeth small, 20 to 25 mm. long, 4 to 5 mm. broad and high; outline linear, slightly curved or straight, crown surface arched from front to rear; uniformly smooth and polished, but finely punctate. Root as high as crown, flat below and on the sides, as broad as high, slightly oblique. Seen from above these teeth resemble those of *Helodus angulatus* N. and W.,\* but differ from them in the shape of the root and in the pores on the enameled surface not being elongated.†

Formation and Locality.—Salem limestone, Lanesville, Spergen Hill, Edwardsville, Romona and Harrison County, Indiana.

\*Paleontology of Illinois, Vol. 2, Pl. 5, Figs. 9-15.

†St. John and Worthen consider *Helodus angulatus* as a variety of *Chomatodus inconstans*, Paleontology of Illinois, Vol. 7, p. 362.

**HELODUS CONICULUS** Newberry and Worthen.

Plate XLI, Figs. 5-7.

*Helodus coniculus* Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 75, pl. 14, figs. 19, 19a.

Teeth small, laterally short, crown composed of a relatively high, rounded, central cone, with short lateral appendages. A sulcus surrounds the crown constricting it, at its junction with root; root nearly as broad as crown, oblique, its vertical face deeply impressed with vermicular cavities; the crown surface is smooth and polished, and uniformly porous throughout.

In the collections from Indiana examined by the writer only one specimen of this species is present. In this specimen the cone is more nearly conical and the lateral appendages slightly longer than in the type.

Formation and Locality.—Salem limestone, Lanesville and Harrison County, Indiana; Burlington limestone, Iowa; Keokuk limestone, Illinois.

**HELODUS INCISUS** Eastman.

Plate XLI, Figs. 10-12.

*Helodus incisus* Eastman, 1903, Bull. Mus. Comp. Zool. Harvard College, Vol. 39, p. 204, pl. 5, fig. 54, 54a, 54b.

Teeth small, bilaterally symmetrical, more or less triangular in cross section, the crown rising abruptly into a slightly recurved median eminence, coronal surface uniformly smooth; posterior face strongly convex, anterior face very gently arched almost plane, with a long v-shaped incision; faint ridges extend along the border of the cavity on either side, and a third extends vertically from the angle where they meet to the coronal apex. Lateral expansion of crown short.

The writer has examined a single specimen of this species from Lanesville, Indiana. The tooth is smaller than the type and the apex is more strongly recurved.

Formation and Locality.—Salem limestone, Lanesville and Salem, Indiana.

**HELODUS ROBUSTUS** sp. nov.

Plate XLII, Figs. 22-24.

Tooth about 14 mm. broad by 10 mm. long, central cone very large, rounded, low, almost flat on top, lateral appendages very



small, rounded or angular, projecting about one-fourth the diameter of cone. A deep sulcus surrounds the crown, restricting it from the root. Root nearly as high as the cone, and as broad as the crown, its vertical face deeply impressed with vermicular cavities. The crown surface is smooth and polished, evenly and finely punctate throughout.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

HELODUS sp. indet.

Among the specimens from Lanesville there is part of a crown of an *Helodus* tooth about the size of that of *Helodus coniculus*, but differing considerably from that form in shape and height. It probably belongs to an undescribed species.

HELODUS ELEGANTULUS sp. nov.

Plate XLII, Figs. 27-29.

Type a single imperfect specimen. Teeth of medium size, the crown rising gradually into a low, broadly rounded eminence. Coronal surface smooth, excepting near the edge, where there are several small imbricating folds running parallel with the edge, punctate on the smooth surface with punctae slightly elongated. One edge of tooth straight, the other slightly convex. Ends straight, oblique, slightly narrower than middle. Root short, thick and strong, nearly as broad as crown. Root much worn in type specimen.

The teeth of this species will be readily distinguished from all other helodoid teeth by the imbricating folds of enamel on the crown, and by the shape of the crown.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

HELODUS ORNATUS sp. nov.

Plate XLII, Figs. 38-40.

Teeth very small, median cone relatively large, subacute. Anterior edge of tooth rounded, posterior edge straight. Root very low. A small tuberculate ridge passes from one end of the tooth to the other just behind the middle. Surface of tooth smooth; punctae in surface minute.

This little tooth resembles those described by St. John and Worthen as *Cochliodus leidy* but that form lacks the tuberculate ridge of the present species.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

HELODUS(?) MINUTUS sp. nov.

Plate XLII, Figs. 32-34.

Teeth very small, oval in outline, crown surface uniformly rounded, not punctate. Root short, constricted below crown, excavated in middle, appearing as a ring with a diameter slightly less than that of the crown.

These peculiar little teeth were probably associated with larger teeth in the jaw of the fish, but since it is impossible to determine with which teeth they were associated they are provisionally given specific rank.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

SANDALODUS OCCIDENTALIS Leidy.

Plate XLI, Fig. 33.

*Cochliodus occidentalis* Leidy, 1857, Transactions of the American Philosophical Society (2), Vol. 11, p. 88, pl. 5, figs. 3-16.

*Deltodus stellatus* Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 97, pl. 9, fig. 2 (not fig. 3).

*Deltodus complanatus* Newberry and Worthen, 1866, Ibid., p. 98, pl. 9, fig. 4; Newberry, 1897, Transactions of the New York Academy of Science, Vol. 16, p. 298, pl. 24, figs. 1-7.

*Deltodus occidentalis* St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 150, pl. 9, fig. 9 (not fig. 10); Eastman, 1903, Bulletin of the Museum of Comparative Zoölogy at Harvard College, Vol. 39, p. 200, pl. 4, fig. 38, pl. 5, fig. 53.

*Deltodus intermedius* St. John and Worthen, 1883, Op. cit., p. 153, pl. 9, figs. 14 and 15.

*Sandalodus complanatus* St. John and Worthen, 1883, Ibid., p. 184, pl. 12, figs. 1-4; Eastman, 1903, Op. cit., p. 198.

*Sandalodus occidentalis* Branson, 1905, Journal of Geology, Vol. 13, p. 26-29, pl. 1, figs. 8 and 9.\*

\*In this article the writer incorrectly gives *Deltodus complanatus*, Newberry and Worthen, Paleontology of Illinois, Vol. 4, Pl. 3, Figs. 5, 8 and 12, as synonymous with *Sandalodus occidentalis*.

Teeth triangular in outline. In teeth of average size, 50-60 mm. long, postero lateral border about 1 cm. longer than antero-lateral. The outer end terminates in an acute point; the inner end has the inner angle obtuse, the outer angle acute. Tooth slightly arched longitudinally and transversely, but, as compared with associated species, flat and thin. A low, broad ridge extends from the obtuse angle of the inner end to the outer end. From this ridge the surface declines very rapidly to the thin antero-lateral border and gently toward the postero-lateral border. Alation broad, slightly upturned. Enamelled surface smooth and polished, everywhere finely punctate. Antero-lateral border not modified for articulation with other teeth.

Formation and Locality.—Salem limestone, Paynter's Hill and Salem, Indiana, and Burlington, Keokuk and St. Louis group, Iowa and Illinois.

*SANDALODUS LAEVISSIMUS* Newberry and Worthen.

*Sandalodus laevisimus* Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 104, pl. 10, figs. 6-8.

*Sandalodus grandis* Newberry and Worthen, 1866, Ibid., p. 105, pl. 10, fig. 9.

*Deltodus grandis* Newberry and Worthen, 1866, Ibid., 105, pl. 9, fig. 9.

*Psammodus? rhomboideus* Newberry and Worthen, 1866, Ibid., p. 110, pl. 11, fig. 6.

*Deltodus grandis* J. S. Newberry, 1879, Annual Report of the Geological Survey of Indiana, p. 344.

*Sandalodus laevisimus* St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 186, pl. 12, figs. 8, 9 and (5?)

*Deltodus grandis* Newberry, 1897, Trans. New York Academy of Science, Vol. 16, p. 297.

*Sandalodus laevisimus* St. John, 1902, American Naturalist, Vol. 36, p. 659.

*Sandalodus laevisimus* Eastman, 1903, Bulletin of the Museum of Comparative Zoölogy at Harvard College, Vol. 39, p. 196.

Teeth of large size, sometimes 5 inches in length by 2 inches in breadth, sub-triangular in outline, strongly arched transversely and longitudinally, with strong spiral inrollment at outer extrem-

ity. Antero-lateral border considerably shorter than postero-lateral, slightly concave; inner margin gently and regularly concave. Surface punctation minute and crowded.

Formation and Locality.—Salem limestone, Lanesville and Harrison County, Indiana; Keokuk group, Illinois, Iowa and Missouri.

*SANDALODUS CONVOLUTUS* sp. nov.

Plate XLII, Figs. 42-45.

Type a single tooth with inner end missing. Tooth large, thick and strong, outer end with strong incurling as in *S. laevissimus*, but with the curved part forming only half a circle. A broad, high ridge, with a broad, shallow groove at the top, passes from the outer incurved part diagonally across the tooth to the postero-lateral angle, groove less pronounced on the posterior part of the ridge. Surface posterior to ridge convex to the sharp postero-lateral border. Surface in front of ridge descending abruptly and thence sloping gradually to the thin rounded antero-lateral border. Enamelled surface finely punctate throughout. Inner end of tooth missing.

This species will be readily distinguished from any other of this genus by the high grooved ridge.

Formation and Locality.—Salem limestone, Bedford, Indiana.

*SANDALODUS PORCATUS* Branson.

Plate XLI, Fig. 26.

*Sandalodus porcatus* Branson, 1905, Journal of Geology, Vol. XIII, p. 30, pl. 1, fig. 14.

Length of tooth along antero-lateral edge 34 mm.; breadth above alation 14 mm.; greatest thickness 10 mm. Tooth very thick and strong at the inner end, but becoming thin along the antero-lateral border near the outer end. The postero-lateral border is thick from the outer end to the alation, but becomes quite thin along the margin of the alation. The alation resembles that of *S. emarginatus* in being convex upward and very thick and strong. It occupies considerably more than half the postero-lateral border of the tooth, and diverges from this border at an angle a little greater than 100 degrees. Tooth strongly arched longitudinally.

inally and transversely, excepting at the outer end, where the transverse arching is much less than in *S. laevisissimus* and *S. emarginatus*. The transverse arching near the inner end is much stronger than in any other species of *Sandalodus*. The outer end was probably inrolled as much as in *S. laevisissimus*. Enamel punctation so fine that it can with difficulty be detected with the naked eye. The tooth is peculiar in having a sharp ridge along the higher part running from the outer end to the inner. From the antero-lateral border six small ridges with sharp crests pass upward and forward joining the large ridge at the top. The posterior one of these ridges is quite strong, but they decrease in size progressively toward the anterior end of the tooth, and the anterior one is very faintly marked. No lines of growth are present.

Formation and Locality.—Salem limestone, Salem, Indiana.

Note.—Neither the original figure of this tooth nor the one in this article show the strong ridge along the top of the tooth.

PSEPHODUS LATUS? St. John and Worthen.

Plate XLI, Fig. 23.

*Psephodus latus* St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 72, pl. 2, figs. 1-3.

St. John and Worthen include several forms of teeth in this species, and one tooth from Ellettsville, studied by the writer, seems to belong here. The teeth described by St. John and Worthen are probably posterior mandibular or maxillary rather than mandibular median.

The tooth from Ellettsville is posterior mandibular or maxillary. Tooth small, inner margin straight, posterior margin broadly rounded, outer margin short, slightly convex, anterior margin short, straight, meeting the outer margin at an angle of about 60 degrees. Tooth considerably arched in both directions, summit of arching running parallel with and near the inner margin. Punctate small and remote.

Formation and Locality.—Salem limestone, Ellettsville, Indiana, and St. Louis limestone, Illinois and Missouri.

PSEPHODUS(?) sp. indet.

Among the specimens from Lanesville there is a small imperfect tooth that resembles closely the teeth of *Psephodus latus* in

shape and size, but the punctae are larger and closer together than in the teeth of that species. It probably represents an undescribed species of *Psephodus*. Tooth too imperfect for specific description.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

*PSEPHODUS REGULARIS* St. John and Worthen.

Plate XLI, Fig. 32.

*Taeniodus regular* St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 77, pl. 13, fig. 11.

Posterior teeth large, subrhomboidal in outline, moderately arched in the direction of enrollment, antero-lateral border very oblique in its forward and outward course, postero-lateral border almost parallel with it. Inner margin broadly arched from the subacute posterior angle round the base of the coronal prominence, thence with a slight concavity on the way to the obtuse anterior angle. Two-thirds or more of the coronal surface is occupied by a posterior prominence which is gently and regularly arched transversely, the anterior slope descending into the very shallow concavity of the anterior portion of the crown, which is abruptly truncated at the articular border. Greatest breadth of tooth across the inner margin 45 mm., length of anterior border to point of enrollment about 22 mm., nearly two-thirds that of the postero-lateral border. Punctae small and uniform save in the axes of the transverse furrows, where they often present irregular elongate orifices.

Formation and Locality.—Salem limestone, Bedford and Lanesville, Ind.

*DELTODUS SPATULATUS* Newberry and Worthen.

Plate XLI, Fig. 34.

*Deltodus spatulatus* Newberry and Worthen, 1866, Paleontology of Illinois, Vol. 2, p. 100, pl. 4, fig. 7; 1870, Ibid., Vol. 4, pl. 3, fig. 11.

*Cochliodus costatus* (pars) Newberry and Worthen, 1870, Ibid., p. 364, pl. 3, fig. 12 (not fig. 10).

*Deltodus spatulatus* Newberry, 1879, Annual Report of the Geological Survey of Indiana, p. 346.

*Deltodopsis? convolutus* St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 165, pl. 11, figs. 11 and 12.

*Cochliodus costaus* (pars) St. John and Worthen, Ibid., p. 167.

*Deltodus latior* St. John and Worthen, Ibid., p. 145, pl. 9, figs. 11 and 12.

*Deltodus spatulatus* Newberry, 1897, Transactions of the New York Academy of Science, Vol. 16, p. 292, pl. 19, figs. 8-11.

*Deltodus spatulatus* Eastman, 1903, Bulletin of the Museum of Comparative Zoölogy at Harvard College, Vol. 39, pl. 4, figs. 41 and 42, pl. 5, fig. 55.

*Deltodus spatulatus* Branson, 1905, Journal of Geology, Vol. 13, p. 31, pl. 1, figs. 10, 12 and 13.

Posterior teeth triangular in outline, strongly arched longitudinally and transversely. A broad, rounded ridge extends from the outer end to the middle of the inner end; inner end broadly rounded; alation of posterior-lateral border narrow, only slightly upturned, antero-lateral border thick, slightly concave, modified for articulation with anterior teeth.

Formation and Locality.—Keokuk, Harrison County, Indiana; Salem limestone, Salem and Lanesville, Indiana; Kinderhook and Burlington, Iowa and Illinois.

This species has not heretofore been reported from above the Keokuk.

#### DELTODUS TRILOBUS St. John and Worthen.

Plate XLI, Figs. 27-28.

*Deltodus trilobus* St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 148, pl. 9, fig. 8.

Median tooth of medium size, wedge-shaped in outline, moderately arched and rather strongly inrolled. Posterior-lateral or oblique border converging toward the outer extremity at an angle of about 15 degrees with the opposite border. Basal portion of moderate depth, rather deeply and angularly channeled. Antero-lateral border proportionately short, the round anterior coronal ridge imbeveled to the relatively shallow, channeled, imbeveled basal rim. Inner margin obliquely produced backward from the obtuse anterior angle to the broadly rounded base of the principal

coronal ridge. The principal ridge occupies half or more of the transverse diameter of the coronal region, rising into a high rounded crest, the anterior slope steep and terminating in a narrow depression outwardly defined by the low narrow anterior ridge along the antero-lateral border. Worn coronal surfaces exhibiting fine closely arranged punctae.

One specimen studied by the writer is about 15 mm. across inner end and more than 30 mm. along the antero-lateral margin.

Formation and Locality.—Salem limestone, Spergen Hill, Indiana, and Jersey County, Illinois.

DELTODUS CINCTUS Newberry.

Plate XLII, Fig. 41.

*Deltodus cinctus* Newberry, 1879, Geological Survey of Indiana, p. 344.

*Deltodus parvus* St. John and Worthen, 1883, Paleontology of Illinois, Vol. 3, p. 131, pl. 9, figs. 1-5.

Tooth of medium size, spatulate in outline; much arched in both directions, thick and strong; greatest breadth 25 mm., length 55 mm., upper surface marked transversely by a series of shallow sulci, which curve downward and terminate in the lateral margins, causing these to be slightly crenulated. In the middle portion of the crown these furrows are about 5 millimeters apart; near the lower margin they more closely approximate, and are somewhat irregular; surface uniformly enameled, and rather closely punctate.

It is the writer's opinion that *Deltodus parvus* St. John and Worthen is synonymous with *Deltodus cinctus*. The teeth described by St. John and Worthen are smaller than those of *D. cinctus*, but in other respects agree with them.

As *Deltodus cinctus* has never been figured it is fortunate that the specimen figured here was identified by Professor Newberry himself. The specimen is from the collection of Walker Museum, University of Chicago.

Formation and Locality.—Salem limestone, Greencastle and Harrison County, Indiana; St. Louis group, Pella, Iowa, and St. Louis, Missouri.



## DELTODUS sp. indet.

Plate XLI, Fig. 24.

A fragment of a tooth from Lanesville is referred with some doubt to this genus. It differs from *Deltodopsis sanctiludovici* in the area between the postero-lateral border and the median ridge being plane, and the area in front of the ridge being concave.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

## DELTODOPSIS? BIALVEATUS St. John and Worthen.

Plate XII, Figs. 8-9.

*Deltodopsis? bialveatus* St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 169, pl. 11, figs. 15-18, includes varieties *keokuk* and *convexus*.

In the collection of G. K. Greene there is one imperfect tooth that probably belongs with the group of teeth described by St. John and Worthen as *Deltodopsis bialveatus*. The crown shows a shallow depressed area in the middle near the inner end and the root is narrower than the crown. Lines of growth are deeply impressed.

It seems probable that this is a median tooth of some species of *Deltodus*.

Formation and Locality.—Salem limestone, Lanesville, Indiana; Burlington and Keokuk limestones, Iowa.

## ORODUS NEGLECTUS? St. John and Worthen.

Plate XLII, Figs. 35, 36.

*Orodus neglectus* St. John and Worthen, 1875, Paleontology of Illinois, Vol. 6, p. 308, pl. 6, fig. 26.

A fragment from Lanesville consisting of the median part of a medium-size tooth is referred to this species with some doubt.

The median cone is unornamented save for a few denticles along the posterior edge of the base and a tuberosity on the anterior edge of the base.

Formation and Locality.—Salem limestone, Lanesville, Indiana; St. Louis group, Illinois and Iowa.

## ORODUS SIMPLEX sp. nov.

Plate XLII, Figs. 25, 26.

Type a little more than half of a well preserved tooth. Tooth of medium size, fragment preserved having the central cone and three lateral cones on one side, central cone about twice as large as first lateral cone, second and third lateral cones smaller than first. Central cone ornamented with four low, rounded vertical ridges that disappear before reaching the apex, lateral cones with little or no ornamentation.

Formation and Locality.—Salem limestone, Edwardsville, Indiana.

## DESMIODUS SALEMENSIS sp. nov.

Plate XLII, Figs. 12-14.

Tooth large, 12 mm. broad by 10 mm. high. Crown subtriangular in outline, inferior angles slightly rounded, apex appearing truncated on account of the curving downward and outward of the tip. Lateral cutting edges slightly wavy in outline, but with little or no denticulation. The lower border of the crown on the outer or concave surface of the tooth curves upward, running nearly parallel to the cutting edges. The lower margin of the crown is nearly straight on the convex face. Between the margin and the cutting edge the surface of the crown is concave transversely on both the concave and convex surfaces. From the transverse concavity on the convex surface a narrow concavity passes vertically to the tip of the tooth. The coronal surfaces are polished and smooth in the lower portion, but near the crest are marked by shallow narrow furrows, which are almost vertical and parallel at the cutting edge, but turn inward lower down, branch and cross one another, forming small hexagonal figures.

Tooth much constricted at junction of crown with root, root nearly as broad as crown, abruptly thickened near the lower edge, convex surface with deep short vertical furrows and narrow ridges.

This species resembles *D. costelliferous* St. John and Worthen, but differs from it in being more than four times as large, in the shape of the crown and in the comparatively greater breadth of the root.

Formation and Locality.—Salem limestone, Paynter's Hill, Indiana.

## CTENACANTHUS PELLENSIS? St. John and Worthen.

Plate XLI, Fig. 25.

*Ctenacanthus pellensis?* St. John and Worthen, 1883, Paleontology of Illinois, Vol. 7, p. 237, pl. 21, fig. 2.

This species is represented by fragmentary material from Salem in the collection of the University of Chicago. It was described from fragments; but the present specimens furnish no new facts about the species.

Spine thick, gradually tapering, obtuse wedge-shaped in cross section, the posterior side deeply excavated by the open trough of the pulp cavity. Lateral surfaces gently convex, somewhat sharply arched into the rounded or subangular anterior edge. Surface ornamentation consisting of numerous delicate longitudinal costae more or less regularly diminished in size from the anterior edge, more frequently bifurcated and deflected on nearing the postero-lateral angles, where they cease at the anterior beveled edge. In front the costae present plain, rounded, enameled crests spaced by narrow intervening sulci, their lateral edges studded with delicate downward curved transverse carinae or tubercles; the third rib from the dorsal edge shows more or less distinct undulations and the fifth rib is surrounded by small steltate tubercles more or less variable in the details of surface sculpture and disposition, their apices directed upward.

Formation and Locality.—Salem limestone, Salem, Indiana; St. Louis group, Pella, Iowa.

## CTENACANTHUS BELLUS sp. nov.

Plate XLII, Figs. 19-21.

Types two fragments from near the middle of a medium-sized spine. The spine resembles that of *Ctenacanthus keokuk*, but differs from that form in the greater length of the nodes, in only the three or four anterior costae bearing nodes, in the slenderness of the costae, and the small size and approximation of the posterior costae. Some of the small costae several rows back of the edge bear incipient approximated enlargements, but most of them are smooth. The anterior edge is very thin and bears small tubercles, space between tubercles about twice the width of the tubercles. Along the postero-lateral angles there is a row of moderately

strong tubercles that project outward at right angles to the lateral face of the spine. Pulp cavity small, subtriangular. The nodes on this spine are longer than in *C. longi-nodus* Eastman.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

gen. et. sp. indet.

Plate XLII, Figs. 30-31.

Among the specimens from Lanesville, there is a peculiar little tooth the relations of which have not been determined. Tooth not quite twice as long as broad, one end much broader than the other, nearly straight and slightly oblique, narrower end rounded. Crown surface low, marked by several imbricating ridges. Ridges quite strong over most of the surface, weak in a narrow strip along one edge. Root cartilaginous.

Formation and Locality.—Salem limestone, Lanesville, Indiana.

#### JAW OF COCHLIODONT.

Plate XLII, Fig. 37.

In the collection of Walker Museum there is one specimen consisting of a nearly complete right ramous of a mandible of an Elasmobranch. It seems to belong to a large Cochilodont, probably *Cochliodus* or *Deltodus*, but the writer has not been able to find any teeth that fit it in the collections that he has studied. The dentition of the right ramus seems to have consisted of three teeth, a large posterior, smaller median and small anterior tooth.

Formation and Locality.—Salem limestone, Salem, Indiana.

Besides the species described in this paper, the following have been reported from the Salem limestone of Indiana: *Antliodus aruatus* Newberry and Worthen, *Antliodus minutus* Newberry and Worthen, *Archaeobatis gigas* Newberry and Worthen, *Chomatodus angustus* Newberry, *Chomatodus obliquus* Newberry, *Chomatodus pusillus* Newberry and Worthen, *Chomatodus selliformis* Newberry, *Copodus marginatus* Newberry, *Lisgodus affinis* Newberry, *Orodus colletti* Newberry, *Sandalodus minor* Newberry and Worthen, *Thrinacodus bicornis* Newberry, *Polyrhizodus littoni* Newberry and Worthen, *Psammodus glyptus* St. John and Worthen.